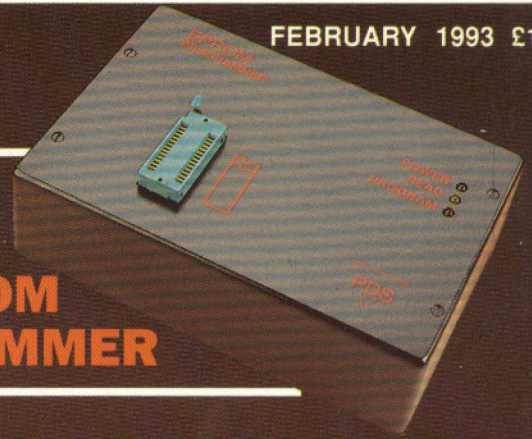


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# ELECTRONICS TODAY INTERNATIONAL

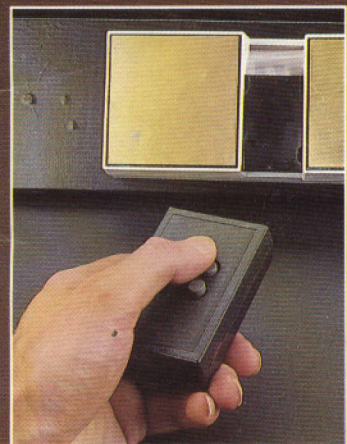
## EPROM PROGRAMMER



## OP-AMPS TECH TIPS

## AMIGA CONTROLLED LIGHTSHOW

## Build this Infra-red four channel transmitter



## using our PCB

Please tell  
your retailer  
if the PCB  
is missing

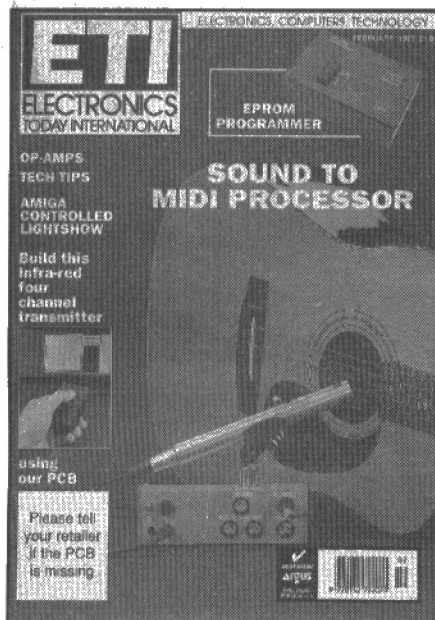
# SOUND TO MIDI PROCESSOR



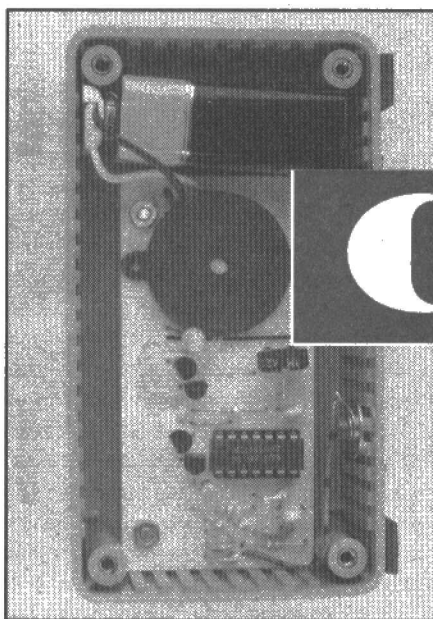
  
**BEST VALUE**  
**Argus**  
 SPECIALIST  
 PUBLICATION



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## Editorial

by Paul Freeman

**I** trust the seasonal festivities have not only given you time to reflect upon a year that quite a few of us would like to forget but also a time to look forward with renewed vigour to the year ahead. A more hopeful time perhaps for the electronics industry for they have not been immuned to the ravages of the recession.

Lack of sales in brown and white goods has caused a knock-on effect to occur all the way back down the chain to component suppliers.

### Toobs, Bottles And Emulators

Hi-fi buffs who can tell the audio difference between a valve amp and a solid state transistor version will be interested to know that a solid-state 'tube emulator'

has been developed in the US. Apparently audiophiles say the new amplifier is indistinguishable from the real thing. The 'tube emulator' is dropped into the traditional circuit where the valve was. Further news of this new device will appear next month under our News Stateside column. If all are agreed with the audio characteristics of the tube emulator then we might just see the end to valves being used for audio purposes. The clear disadvantages of valve equipment are weight and bulk but on an analytical level it is difficult sometimes to see where the attachment still remains. Looking into the glass envelope, some would say you can almost see them working!

Readers will note that due to pressure of space, the AutoMate mixer article does not appear in this issue.

# OPEN CHANNEL



A serious global environmental concern takes up Open Channel this month. It's an issue which all readers of ETI will be aware of, I'm sure. It affects not just us in our present environment, but the environment of generations

I'm talking about the use of chlorofluorocarbons (CFCs). You'll all have heard of them, even if you're not totally aware of what they are or what they're doing to the environment.

Chlorofluorocarbons are chemical compounds, containing various proportional mixtures of Chlorine, Fluorine, Carbon and sometimes Hydrogen. As such, they present little harm to the planet. Stuck in a bottle on a laboratory shelf they're pretty innocuous, but when they get out of the laboratory shelf bottle they turn into vaporous demons which have already changed our environment to a considerable degree - almost beyond repair.

The problem arises when chlorofluorocarbon vapour rises up into the air, through the atmosphere, right up to the stratospheric layer of ozone around earth. The stratospheric ozone layer has one several functions - one is to filter and absorb ultra-violet radiation from the sun.

Ozone is a gas ( $O_3$ ) which occurs in all layers of the atmosphere and actually only ever occurs in very small concentrations. However, concentration is greatest in the so-called ozone layer, so scattering ultra-violet light.

Continual processes occur in the ecosphere which for millions of years have maintained a chemical balance, keeping the ozone layer constant. Chemicals rise up through the atmosphere, break down due to energy from the sun, and combine with oxygen atoms from ozone. On the other hand, energy from the sun breaks down oxygen into single atoms, which combine with oxygen molecules to form ozone. And so the cycle continues... unless, too many chemicals rise up through the atmosphere.

Chlorofluorocarbons, are the chemicals which threaten this ozone production-breakdown balance. They are very, very stable, so rise high up in the atmosphere - to the ozone layer - before they can be broken down by sun light.

Not only are there now too many chlorofluorocarbons in the ozone layer, breaking down ozone at a faster rate than the natural cycle can replenish it, but the situation is made much worse because they are so stable they can remain there for some time before breaking down. Even if a total ban on chlorofluorocarbon was issued and its use was stopped today, the amount of chlorofluorocarbon present in the atmosphere in one hundred years time could still be about a third of current levels.

The whole thing has grave effects on the environment. If the ozone layer partially breaks down (causing the so-called 'holes' in the layer, reported in the media) greater amounts of ultra-violet light from the sun reach earth's surface. This can cause immediate and long-term damage to plants, animals, humans and earth itself. Increased risk of cancer and changing climates, are possible hazards.

In the past (and, indeed, even in the recent past) the electronics industry has been one of the greatest culprits in

the crime of ozone layer breakdown. Manufacturing processes are usually pretty dirty, so assemblies (that is, printed circuit boards) require cleaning. Unfortunately, the easiest and cheapest method (cheapest in terms of monetary cost alone, of course) of cleaning printing circuit boards is to dunk them in hot chlorofluorocarbon. As a solvent, chlorofluorocarbon is superb - it dissolves and dislodges most types of dirt, grease, and gunge on assemblies. As a vapour, it is lethal to the environment.

In 1987, in Montreal, worldwide government heads met to decide on a progressive phase-out of chlorofluorocarbon use. The Montreal Protocol was the result; a historical statement of intent by world governments to do the job - it's not often you can get more than one government in a room to agree anything, after all. By the turn of the century it was hoped the use of chlorofluorocarbons would be stopped.

As it happens the electronics industry has risen to the challenge, phasing out chlorofluorocarbon use quicker than most other industries, to the level where by the end of this year it will finish in the electronics industry.

Now I think that's a tremendous thing, and worth being proud of. To be honest, it was not so much an agreed decision within the industry to do it because of an environmental conscience. Instead, the impetus has been made because new and cheaper manufacturing processes (specifically surface mounted technologies) have recently been instigated, which simply require less cleaning of assemblies. Indeed, some new processes do not require cleaning at all.

Still, let's not run ourselves down too much, we're among the first to be able to say we're about to stop using chlorofluorocarbons and that's a very large feather in our very large collective cap. After all, the Montreal Protocol was never intended to prevent industries using chlorofluorocarbons by law, or by force. Its primary aim was to make the use of chlorofluorocarbons so financially unrewarding that the various industries would be persuaded to use other safer processes. The electronics industry has simply been one of the first industries to benefit from newer (cheaper) processes not requiring chlorofluorocarbons.

But, unfortunately, the story doesn't stop here. While chlorofluorocarbons form the primary cause of alarm environmentally, other compounds are capable of doing the same thing to the environment, to a lesser degree. What we have to ensure is that these other compounds aren't simply used in the place of chlorofluorocarbons. While they may cause lesser damage than chlorofluorocarbons they could still cause some damage.

I for one do not want to be labelled as a person who instigated the partial or total destruction of our children's children's world. Do you?

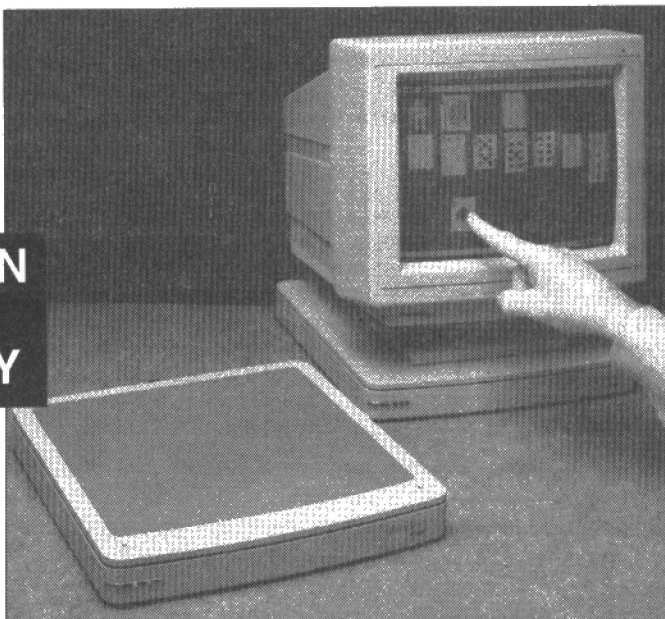
While the chlorofluorocarbon issue is paramount, in wider terms it is merely the first issue tackled globally. Certainly we have got our electronic house in order regarding chlorofluorocarbons, but in the global village there are many more houses, and many more issues.

Keith Brindley

## THE LATEST IN TOUCH TECHNOLOGY

A new touch technology, compatible with almost any display monitor, has been launched throughout Europe by Ellinor Technology.

The TouchMate is a force sensing platform less than 2" high onto which a monitor is placed. When the monitor is touched, whether by a finger, glove or stylus, the force of the touch causes a movement of the top plate relative to its base, typically of the magnitude of a thousandth of an inch. Internal force sensors detect this movement in the x, y and z



directions enabling it to measure the location of the touch and the level of pressure exerted.

One advantage is that users can simply place their monitor on the sensor, connect it to their computer's serial port and carry out a simple calibration procedure,

from which point the system is ready for use.

It is said to be compatible with virtually any size and make of monitor so users can convert their existing monitors to touch screen.

There is no effect on the image quality of the monitor since no

glass panel or membrane is placed in front of the screen.

The system is based on force detection and can therefore be operated by any pointer, finger, gloved hand or stylus.

Point of information applications and interactive training systems are expected to be the main markets for the new product. The screen operates at angles of up to 45 degrees and is environmentally durable which makes it well suited to regular public use in retail information applications. It is also expected to be popular in unattended external applications such as ticketing, tourist information and financial services.

It has a touch resolution of 40 points per inch and noise filtering techniques are employed to ensure that external vibrations do not affect accuracy. TouchMate will retail at £650-00.

For further information please contact:

**John Rodger at  
Ellinor Technology  
Tel: 0734 311066**

## NEW INKJET PLAIN PAPER FAX

City Electronics & Telecommunications - suppliers and installers of a wide range of telephone systems - has added two new, plain paper, ink inject Fax machines to its telephone equipment range.

Although the plain paper Fax has been on the market for twelve months with laser printing, the ink inject method reduces the cost of using a plain paper Fax and could broaden the market for this type of facsimile.

For professional services such as that offered by accountants, solicitors, and architects, the plain paper Fax is essential and it is

more affordable. It produces good copy, on plain paper, to the same quality expected from a standard photocopier.

The two new units, manufactured by Panasonic, are the Panafax UF311 and Panafax UF312. A special feature of both machines is that a message can be transmitted to up to fifty-two stations in sequence rather than calling stations individually.

If the recording paper or ink in the inkjet cartridge should run out, the message is stored in memory and automatically printed when new paper or an ink cartridge is loaded. In the case of

failure, the units will automatically re-dial and transmit from the page where disconnection occurred, without re-sending from the first page, thereby reducing time and telephone line costs.

With either machine the user can, if required, share a single line for Fax or voice - the machines will automatically determine whether its for Fax or voice and a telephone answering machine can be added. Automatic reduction and delayed sending are also standard features.

The single touch memory allows for telephone number storage: twelve basic numbers for the

UF311, which can be expanded to twenty-eight if required; and twenty-eight numbers for the UF312, which can be expanded to sixty.

The UF312 can store selected documents in the memory and then programmed to be transmitted later. When printing from memory this machine is still able to receive or transmit.

City Electronics and Telecommunications retails the UF311 for £1495 and the UF312, for £1895.

For more information:  
**Tel: 081-201 9500  
FAX: 081 201 9600**

## GOVERNMENT SUPPORT FOR DAB

National Heritage Secretary Peter Brooke has given the Government's full support for Digital Audio Broadcasting (DAB), saying it offered more choice to listeners and gave British manufacturers a great opportunity to exploit a new market.

DAB will bring near CD-quality sound to radio for the first time. The technology could first be introduced for car radios in 1995; domestic sets could benefit soon thereafter. It will also pro-

vide major benefits to broadcasters and listeners through its more efficient use of the radio spectrum, offering more radio channels for each frequency band than are available now.

Mr Brooke urged British manufacturers of radio and electronic equipment to seize the opportunities offered by DAB technology, saying:

"The way forward is now sufficiently clear for broadcasters and manufacturers to prepare for the

introduction of DAB services in the next few years.

"With an average of four or five radio sets in every home in this country, the opportunities for manufacturers prepared to produce DAB sets at reasonable prices are obvious. At this stage there is no reason why UK manufactured sets could not be first into both the home and European markets."

Mr Brooke also called upon the media to help stimulate wider

involvement in the debate by informing the public about the technological and commercial changes which were affecting broadcasting:

"The links between policy development, technological change, manufacturing, programme production and consumer choice reinforce the need for people to be well-informed if they are to make sensible choices."

## ENGINEERING PHYSICS DEGREE APPLAUDED

The lead editorial in a recent issue of *Physics World*, the members' journal of the Institute of Physics, has singled out Sheffield Hallam University's BSc (Honours) Engineering Physics as inspirational and unique in Europe. The course meets the need of advanced manufacturing countries for professionals who combine physics training with related disciplines, notably engineering.

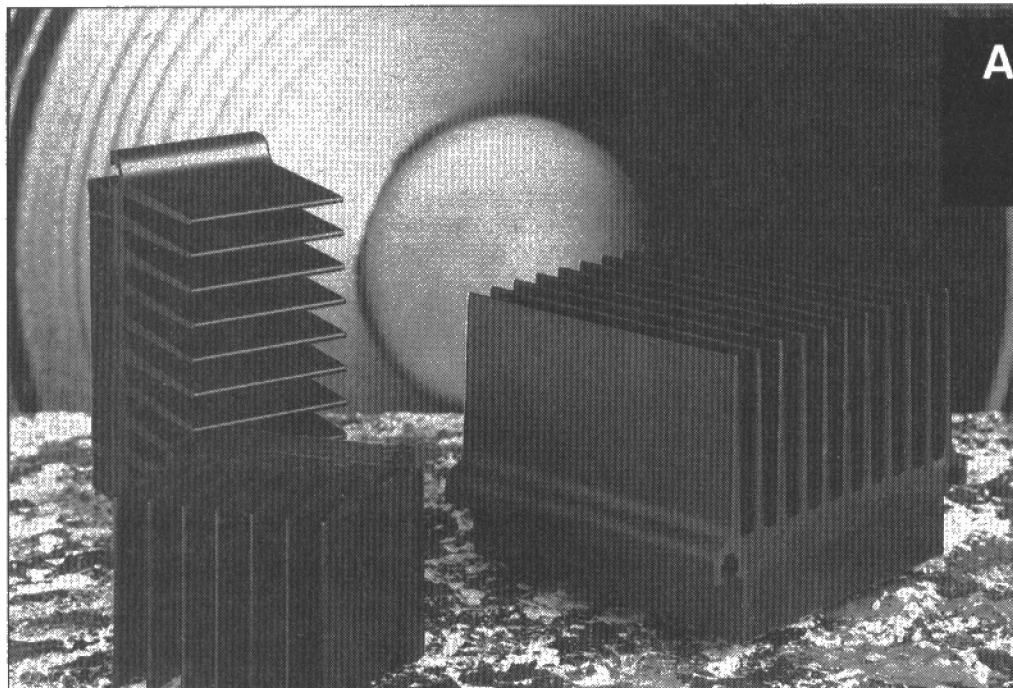
Physics World states: "Sheffield Hallam University (hitherto Sheffield City Polytechnic) is setting what appears to be a precedent in Europe: an honours BSc in engineering physics designed to deliver skills not only in physics but in engineering judgement - in other words, a capacity for subjective decisions on design and cost-effectiveness".

A testament to the praise re-

ceived is the excellent record of employment for graduates of the course despite the ongoing recession. Forward thinking employers are keen to recruit industrial placement students for work experience and graduates for permanent employment.

The professional status of the course has recently (May 1992) been accredited by the Institute of Physics, the Institution of Electri-

cal Engineers and the Engineering Council as the first and so far only physics degree which directly satisfies the educational requirements for membership of both institutions and the status of Chartered Engineer and Chartered Physicist. The course offers a direct route to the status of a Professional Engineering Physicist.



### AUDIO POWER AMPLIFIER MODULES

to high power stage amplifiers.

The modules are manufactured in three types; Bi-polar, MOSFET and Class A and are encapsulated with an integral heatsink. With power ratings from 15 to 180W RMS, the amplifiers produce very low THD; the MOSFET series is less than 0.005% and input sensitivity is only 500mV for full output.

To compliment the modules three power supply boards are available which, together with ILP's toroidal transformers allow high VA rated, split rail power supplies to be easily produced.

For further information please contact:

**Cirkit Distribution Ltd**  
**Tel: 0992 441306**

**C**irkit Distribution is now stocking the complete range of ILP audio power amplifier modules.

The modules provide a range of building blocks for making high quality audio amplifiers with the

minimum of additional components. Applications range from low power hi-fi quality amplifiers

## SuperJANET TO THE RESCUE

**L**ife saving surgery could be 'seen' via the telephone with a new high-speed fibre optic network from BT which will link computer systems in universities and polytechnics throughout the UK.

The network called SuperJANET (Joint Academic Network) will allow medical students to watch operations and learn new surgical techniques from hundreds of miles away.

BT was awarded the contract for the network by the Information Systems Committee (ISC) of the University Funding Council (UFC). The negotiations have been on the basis of an £1.8 million project over four years, incor-

porating a review period at the end of the installation of the pilot stage.

Under the contract, BT will collaborate with the SERC/UFC (Science and Engineering Research Council/Universities Funding Council) Joint Network Team to design and implement the new network. It will augment the existing private JANET network created during the early '80s.

The new network is needed to support advanced applications requiring a mixture of voice, data, image and video communications.

SuperJANET will be able to transmit information up to 100,000 times faster than the standard telephone network, with

the initial phase of the project linking sites at Cambridge and Manchester Universities, Rutherford Appleton Laboratory, University College London, Imperial College London and Edinburgh University.

The network is designed to use the most up-to-date communications technology - synchronous digital hierarchy (SDH) - together with BT's new Switched Multimegabit Data Service (SMDS).

SuperJANET will provide a wide range of new applications and will play a major role in supporting teaching and research activities. Initially, these include distance teaching, electronic pub-

lishing, library document distribution, high quality medical imaging and multimedia information services.

Dr Alan Rudge, BT's Managing Director for Development and Procurement, with responsibility for all of BT's technical research activity, added: "BT is extremely pleased to have won this contract and we view the opportunity to work with the universities as a critically important strand in our development programme for high speed network services. We plan to collaborate in a number of areas of mutual interest, not least the development of an advanced broadband switching platform for SuperJANET."

## PC VIDEOPHONE SERVICE

**B**T and IBM are set to extend their collaboration on multimedia by making PC videotelephony available to other operating systems including Apple, PS2 and PC compatibles. In April 1992 BT and IBM announced that they would co-oper-

ate on a personal computer videophone product using specially developed software.

BT's PC videophone hardware, which conforms to the H.320 series of international videotelephony standards, and IBM's Person to Person 2 (P2P)

software will allow people to participate in desk-top conferences by enabling them to see each other and exchange documents via their PCs. IBM's P2P software can also be used with H.320-compatible video over public telephone networks.

BT and IBM UK will have a PC videophone product comprising a PC card, camera and handset on the market by the third quarter of 1993. The expanded P2P support for this technology will be available soon after.

## SURFACE RESISTIVITY METER

**T**echnotrend Ltd of Farnborough has launched a revamped version of its SRM 30 Surface Resistivity Meter. The SRM 30 is an instrument that measures both surface resistivity and resistance to ground. The new version gives measurements of surface resistivity over a range from  $10^3$  to  $10^{13}$  ohms with a clear indication whether a surface or material is conductive, static dissipative or insulative. Accuracy of measurement is assured by means of a system of independently sprung electrodes which can accommo-

date considerable irregularity of the surface under investigation.

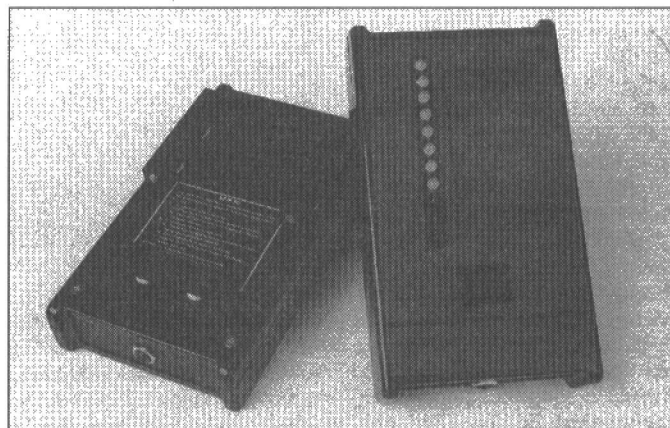
Powered by a standard 9V battery the SRM 30 requires a minimum of operator training. It has applications in such static sensitive environments as microelectronics component assembly areas, computer rooms, quality control, laboratories and hospitals.

For further information contact:

**Technotrend Ltd.**

**Tel: 0252 373242**

**Fax: 0252 373440**



## PAGING SYSTEM HELPS CUT CRIME

**T**he first paging system in the UK to be used by Neighbourhood Watch schemes has been supplied by Hutchison Telecom. The early warning paging system has been introduced into the Birmingham area for both West Bromwich and Sutton Coldfield's Neighbourhood Watch schemes, making them the first and the most technologically advanced schemes in the UK.

The paging system means that police are now able to send messages immediately to Neigh-

bourhood Watch co-ordinators on matters varying from suspect cars to possible gangs of burglars or vandals operating in certain streets or areas, simply by telephoning details into Business Watch's message bank. This automatically alerts all the coordinators using pagers and each member of the group then dials into the message bank to hear the information. In turn the coordinators will alert Neighbourhood Watch members in their area.

According to the latest Home

Office crime figures, burglaries have increased by 16% over the last twelve months, with 173,000 more burglaries recorded by the police in the twelve months ending June 1992. Of these 91,000 were residential burglaries and 28,000 shop thefts, an increase of 11%. Hutchison Telecom hopes that this new technology will beat the increasing crime rate.

At the trial launch Mr Dave Gerard, Neighbourhood Watcher said: "Within minutes we shall get the message and within min-

utes we have 3000 eyes looking out for what we have been given by the police. 3000 eyes is a lot, we only have a few policemen out in their cars, we have got 3000 eyes".

The paging system used in the new trial is the same as that used in Hutchison Telecom's Business Watch scheme which is currently being used to successfully combat crime primarily in businesses and retail outlets.

## PRINCESS ROYAL PRESENTS BBC RADIO 4 AWARD TO OPTICS INVENTOR

**A** device which enables partially-sighted people to magnify written text and make it appear on a television screen has won an award from the BBC Radio 4 programme 'In Touch'. Mr Pat Crane was presented with the David Scott Blackhall Award by the Princess Royal in a ceremony at Broadcasting House in London.

The 'Eezee-Reader' which can be connected to any television set

and enlarge print by up to 40 times secured the award, which is given to someone who has provided outstanding service to people with a visual handicap. The award for £1,000 is funded by the Patients Aid Association from Wolverhampton, and commemorates David Scott Blackhall who worked on the 'In Touch' programme from 1961 until a few weeks before his death in 1981.

Pat Crane's invention consists

of a miniature camera and magnifier in a tiny, hand-held scanner similar in size and shape to a paper stapler. This is mounted like a miniature telephone on a small box into which the television aerial from any domestic set can be connected. The television is tuned into a spare channel and when the camera scans any writing it appears greatly magnified on the television screen.

Pat Crane, an electronics en-

gineer from Ripley in Surrey, runs a small business producing miniature cameras for industrial inspection work. He got the idea for the 'Eezee-Reader' when he saw what pleasure a partially sighted friend got from looking at photographic enlargements which enabled her to see people and things she could not normally see.

## FOUR-IN-ONE INSTRUMENT

**S**AJE Electronics has introduced an MX9000 Multi-Instrument.

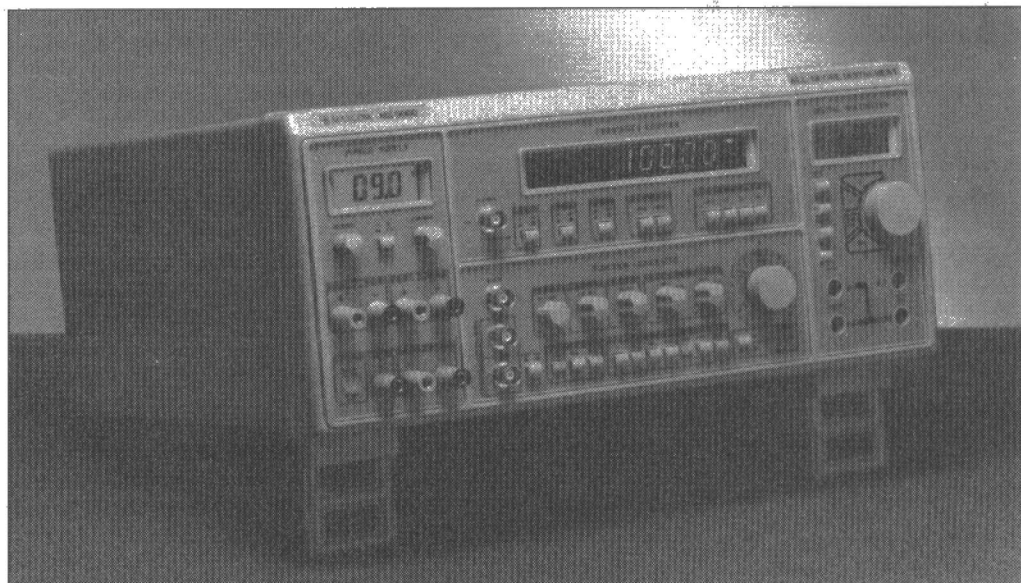
The MX9000 combines four instruments to suit a broad range of applications in both education and industrial markets including development work stations where space is at a premium.

The Instrument includes:

A triple output power supply with LCD display offering 0-50V 0.5A, 15V 1A, 5V 2A with full overcurrent protection;

An 8 digit LED display 1Hz - 100MHz frequency counter with gating rates of 0.1Hz, 1Hz, 10Hz and 100Hz providing resolution to 0.1Hz plus attenuation inputs and data hold;

A 0.02Hz to 2MHz full featured sweep/function generator producing sine, square, triangle, skewed sine, pulse and a TTL output and linear or logarithmic sweep. Outputs of 50R and 600R impedance are standard features; An auto/manual 3 1/2 digit LCD multimeter reading DCV, DCA, ACV, ACA, resistance, and rela-



tive measurement with data hold functions.

The MX9000 comprises four of the most desirable instruments housed in a single unit and built to a high standard. The cosmetic

appearance is extremely pleasing and would be a plus for any bench.

The MX9000 represents good value at £399.00 plus VAT.

For further information please contact:-

**SAJE ELECTRONICS**

Tel: 0223 425440

Fax: (0223) 424711

## VLF RADIO

**T**he ELF and VLF radio bands have hitherto been largely neglected by amateur radio and electronic enthusiasts. This is really quite surprising in view of the fascinating properties of this portion of the electromagnetic spectrum. The evocatively named 'dawn chorus', with its 'tweaks' and 'whistlers', comprises a whole range of natural phenomena generated in the earth's atmosphere. More practical uses of frequencies below 150kHz include broadcasting standard frequency

and standard time services, hyperbolic navigation and communication through sea water or solid rock to submarines, miners and pot-holers. With negotiations between the RSGB and the licensing authorities for an amateur VLF allocation well underway, the neglect of the bottom end of the radio spectrum could be coming to an end.

One British group which is already active in this field is the Cave Radio and Electronics Group of the British Cave Re-

search Association. This group is intent on improving techniques of VLF radio communication with a particular emphasis on its use in cave surveying and cave rescue.

A journal containing a broad mix of practical and theoretical articles is published quarterly. Although most of the group's members are actively involved in caving, there is much here to interest those with a more general interest in VLF radio communication and miscellaneous electronic applications. Recent articles have cov-

ered the principles of inductive communication, antenna design, modulation methods, a design for an ultra-sensitive flash trigger, caveproofing equipment, NiCd battery charging, surveying software and cave detection using geophysical techniques.

Full membership of the group, including subscription to the Journal is £7.50.

For details, contact David Gibson at 12 Well House Drive, Leeds LS8 4BX (Tel 0532481218).

## SONY LAUNCHES FIRST MOBILE PHONE FOR CONSUMERS

**S**ony, is bringing its inimitable touch to the mobile phone market.

The first mobile phone designed specifically for the general consumer has been launched. It is intended to work in conjunction with Cellnet Lifetime, a new service which aims to open up the domestic market by halving usage costs and offering a customer friendly service.

Sony's new phone, the CM-

H333 is small enough to fit in the palm of the hand and will be one of the most compact mobile phones on the market.

"The mobile phone will no longer be the exclusive preserve of the business person" says Tim Woods, Sony's Senior Manager, Personal Telecommunications.

"Like the electronic calculator, or personal computer, its use is set to become universal. The Sony phone will be available to

everyone, whatever their needs. It's size and shape is about the same as a Mars Bar so convenience combined with ease of use will contribute to its success".

The CM-H333 will be priced at £299 and battery life will allow up to 90 minutes talk time with 24 hours stand-by time and there is an optional hands-free kit for use in the car.

"Sony aims to lead the way in personal mobile communications

hardware" concludes Tim Woods. "The new phone, together with Cellnet Lifetime, will do for mobile communications what the Sony Walkman did for music".

**MORE  
NEWS  
NEXT  
MONTH**

...Stateside...

## Eliminating flat batteries

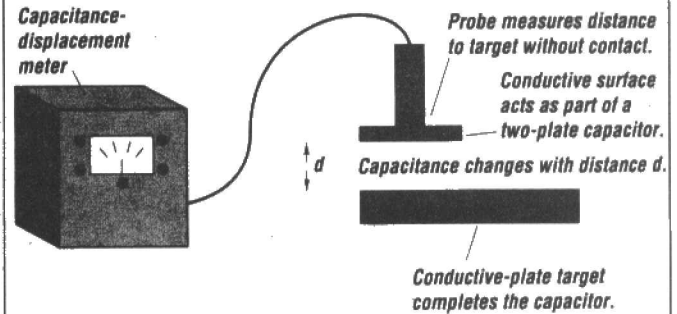
Electronics that help guard against dead batteries has been installed in the 1993 Oldsmobile Achieva. If the trunk, reading, foot, or glove-box lights are left on for 20 minutes while the ignition is off, the circuitry will automatically turn them off. Battery run-down protection also works if a door is accidentally left

## Evaluating cross stepper performance

In evaluating micro-stepper performance most people measure only the starting and stopping position of a multi-step move. What they miss are the details of individual steps and motion profiles that could help them optimize the application.

Dynamic measurements contain more information, but they also are more difficult to make. Sensor requirements are particularly demanding: Resolution must be higher than the smallest micro-step and response time must be two to three times faster than the highest velocity.

## Measuring distance via capacitance

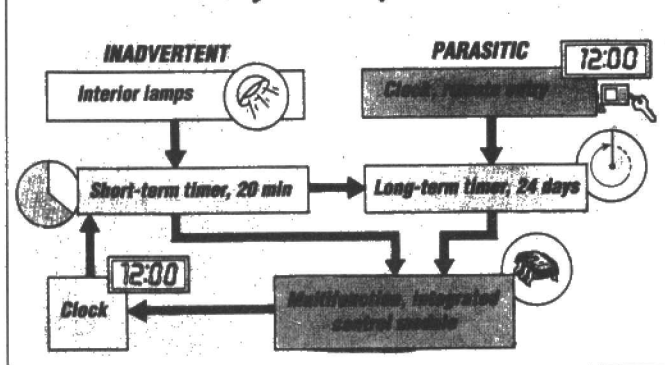


Consider a typical measuring probe that senses a flat tab placed 0.5" from the centre of a motor shaft. For a micro-stepping system with 51,200 steps/rev, a single step corresponds to 61.4 millionths of an inch. The required

response time to gauge stiction, hysteresis, and settling time is on the order of a few hundred microseconds.

Capacitance-based displacement sensors can provide these kinds of numbers.

## Battery run-down protection



ajar. To reactivate any lamp, a driver need only turn on the ignition, turn the light switch off then on, or open the car's front door.

The system also guards against voltage loss if the car is not used for an extended period. After 24

days without use, power to the clock, radio, and remote lock is automatically interrupted to reduce battery drain. Power returns as soon as the ignition is turned on. Clock and radio stations have to be reset.

## 'Self-healing' chips

Scientists at the GE Research and Development Centre have

developed a technology for designing 'self-healing' chips. These are next-generation, integrated circuits that will police themselves for errors caused by malfunctioning circuit elements

and produce signals that compensate for errors the faulted elements would otherwise cause.

Such fault-tolerant chips will be especially important for mission-critical applications aboard satellites and spacecraft, for example, where repairs are difficult or impossible to make and the consequences of errors in processed data can be catastrophic. Intermittent errors introduced by electromagnetic interference and other transient phenomena, as well as errors caused by permanently faulted circuit components, will be detectable and correctable.

The company's new methodology lends itself to the design of both digital and analogue fault-tolerant integrated circuits of the type whose behaviour is represented by state-variable equations. Such circuits, including a large class of filters and controllers, are widely used for diverse control and signal-processing applications.

With the GE approach, validated through both computer simulation and prototyping, error

detection and correction are carried out by a small built-in 'checking circuit' that ties into the chip's primary circuitry at strategic locations.

The checking circuit computes 'check-sum codes' - specified weighted linear sums of the terms on both sides of the state equations that the primary circuit solves in the course of performing its function. If there is a fault, the check-sums do not agree, and an error is signaled. The checking circuit then does an error check of itself, and, if okay, it computes the error value and automatically feeds this value back to the main circuit for error correction.

Fault-tolerant chips are probably two or three years away from their first 'real-life' applications. The company is currently working to extend the technology to the design of complex fault-tolerant circuits of a type that might find aerospace applications, including those that exhibit nonlinear behaviour. The current technique is limited to the design of linear systems.

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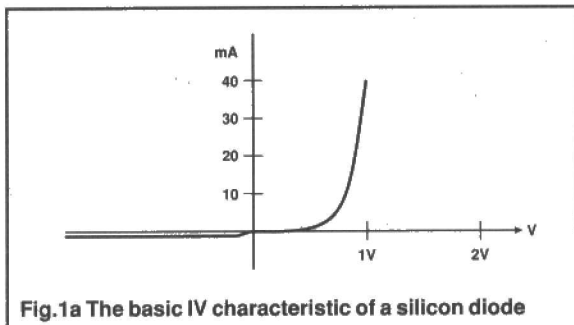
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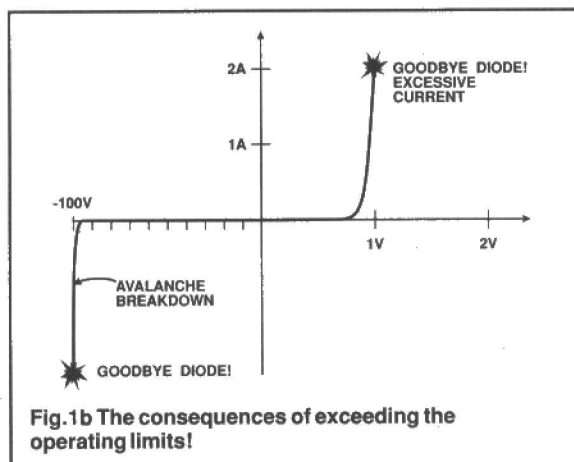
**Paul Chappel  
describes the  
variations available  
on a diode theme**

# Diodes



**Fig.1a The basic IV characteristic of a silicon diode**

**R**umour has it that if you enrol in certain Cordon Bleu cooking courses, the master chef will have you spend the first month perfecting the art of cooking eggs. In this master class I'm going one stage further: not only will I concentrate on one of the most basic of electronic ingredients, the diode, but I'll only be doing any actual cooking with one variety: the tunnel diode. Let's begin by taking a quick look at eggs - sorry, diodes - in general.



**Fig.1b The consequences of exceeding the operating limits!**

The static current-voltage characteristic of an ordinary rectifier diode is shown in Figure 1a. Under reverse bias there's very little current flow, under forward bias the current rises rapidly from about 0.5V onwards, so for practical purposes the diode is essentially a component which conducts in one direction and not in the other within reason anyway, as Figure 1b shows. Too much forward voltage and the diode will burn. Too much reverse voltage and the junction breaks down, and if the current is not externally limited in some way, once again the diode will burn.

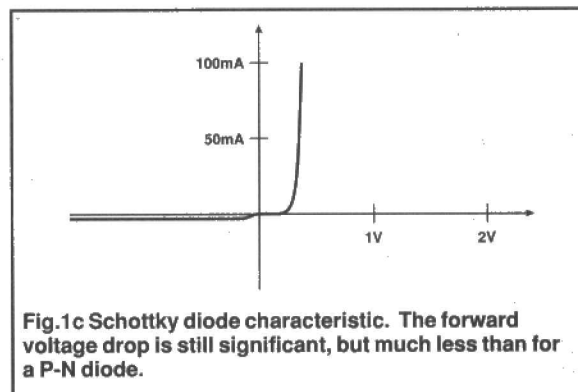
The reverse breakdown is put to good use in the Zener diode. The voltage at which it occurs is pretty repeatable, the conduction is abrupt, so it's quite effective as a voltage reference. A typical silicon signal diode may break down somewhere in the region of 50V to 200V, but by doping the silicon more heavily than usual it's an easy matter to make diodes which conduct at much lower reverse voltages. These highly doped devices are the 'zeners' you use in power supply regulators and suchlike.

If the forward characteristic is not to your liking, that can

be altered too.

Make a junction from aluminium and lightly doped N-type silicon, and you have a schottky diode. It has a considerably lower forward voltage drop than the ordinary P-N junction, so the characteristic is closer to the ideal full conduction (Figure 1c). This is useful in circuits where the power loss from the forward voltage has to be minimised, and for clamping circuits which prevent a voltage exceeding a certain level - the lower voltage drop allows tighter control over the pre-set level. Another good thing about Schottkies is that they work a darn sight faster than ordinary rectifiers - for the physicists amongst you, this is because the current travels by majority carrier only. The problems you get when minority carriers start hanging about round the junction is illustrated by Figure 2, showing the results of some measurements I once made on a 1N4006. I rest my case.

These are the main variations of the basic diode characteristic, but what I want to concentrate on for the rest of the article is devices where the rectifying property is largely irrelevant. By varying the materials, the geometry (the area of the junction, for instance) and the doping levels, it's possible to make a diode do all manner of tricks totally unrelated to its usual purpose. The variation in junction capacitance with voltage can be increased to make a diode which thinks it's a tuning capacitor; different materials can be used to make one that emits light; and various blips can be added to the characteristic of Figure 1a for a diode which will oscillate!



**Fig.1c Schottky diode characteristic. The forward voltage drop is still significant, but much less than for a P-N diode.**

## The Gunn Effect

The normal state of affairs for charge carriers in a semiconductor is that their thermal energy is very much greater than the energy supplied by the electric field. They are a bit like a herd of sheep being driven by a sheep dog: they mill about here and there, but the general drift is always towards the exit electrode.

If a very strong field is applied, it can happen that the energy from the field is comparable with, possibly even greater than, the thermal energy. The result is similar to a flock of sheep fleeing from wolves: if the wolves are some

distance away, the motion of the sheep will be fairly well directed away from them. There may be some random movement, but the motion of the flock will be substantially towards the nearest exit! As the wolves get closer (the applied field is increased further still) the sheep will in such a panic that they'll bump into each other, trip each other up, and the overall motion will actually be slower than before.

In the wolf situation, the farmer arrives to find his remaining sheep very overheated - it's referred to as a hot sheep device. In the electronic version the carriers are also said to be hot, and you'll find reference to hot carrier devices.

In 1963 a chap by the name of Gunn discovered that current oscillations can take place in certain materials, N-type GaAs in particular, under these hot carrier conditions. The physics of the situation is quite tricky, but it revolves around the slowing down of the charge carriers, which gives Gunn devices a negative resistance over part of their characteristic. One way this can give rise to oscillation, I'll talk about that later when we get on to Tunnel diodes. In the Gunn devices, the field which excites the carriers is unstable. Charge carriers that group together distort the field to attract more carriers, which distorts the field further, and so on. The initial clumping takes place in imperfections around the cathode, the bubble spreads to the anode, where it 'bursts', and the whole process begins over again. This all happens rather quickly - at microwave frequencies, in fact - and several Watts of output power are possible.

## Avalanche Diodes

In Zener diodes, the reverse breakdown occurs when charge carriers are accelerated to high enough speeds in the electric field around the junction to dislodge more electrons by colliding with atoms. The newly created charge carriers are also accelerated at high speed, have their own ionising collisions, create still more carriers, until there's a whole avalanche of the things!

An avalanche (or Zener) diode can be adapted to work as an oscillator by adding a length of intrinsic (undoped) semiconductor material either to the end of the diode to give a P-N-I structure, or between the P and regions to form a P-I-N diode.

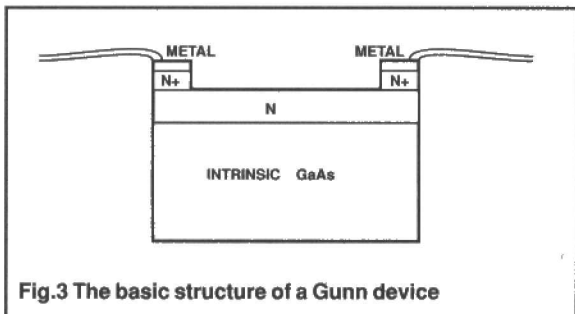


Fig.3 The basic structure of a Gunn device

Unlike Gunn devices, avalanche diodes won't oscillate on their own. They need an external tuned circuit to keep them going. A bias voltage is applied so that the diode is just on the point of avalanche breakdown. If the voltage is increased just a touch, the breakdown will occur, but the current won't rise immediately because the electrons have to make their way through the I region.

If the voltage is decreased again the breakdown stops but there's still a blip of current on its way through.

The trick is to join the diode to a tuned circuit matched to

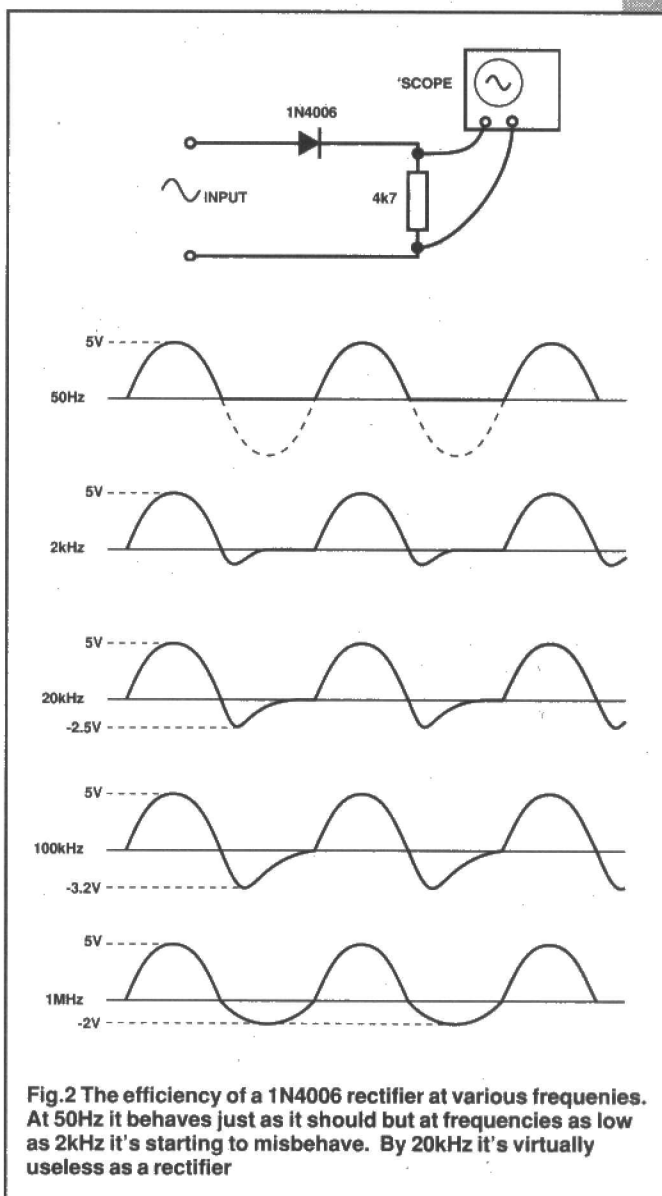


Fig.2 The efficiency of a 1N4006 rectifier at various frequencies. At 50Hz it behaves just as it should but at frequencies as low as 2kHz it's starting to misbehave. By 20kHz it's virtually useless as a rectifier

the drift time of the I region so that the current pops out in antiphase to the voltage. This gives the tuned circuit the boost it needs to keep going; the voltage it creates keeps the breakdowns going, which keeps the blips of charge coming, which keeps the tuned circuit going... And there you have it. An avalanche diode oscillator.

Once again these devices oscillate in the microwave region. The impatt variety which work in the way I've described can produce a fairly high output power, but aren't too efficient (less than 10%). A slightly modified version known as the trapatt can achieve efficiencies of over 50%.

## Tunnel Diodes

In 1964, J. Tunnel discovered ... no, I lie. The tunnel diode was actually invented by a Japanese gentleman. The year I'm not too sure of, so we'll just say it was in the early sixties. On a Tuesday.

A tunnel diode is made from an ordinary P-N junction, the special feature being that the doping on both sides is very heavy indeed. As with people who are doped up to the eyeballs, the materials are said to be degenerate, which means that the majority carrier energy levels on either side of the junction overlap. In this condition a process known as tunneling can occur: charge carriers can disappear from one side of the junction and magically reappear on the other side.

without ever having had the energy to make the jump. The rule is that they must end up the same energy level they started at, which is only possible when the energy bands overlap.

The notion of tunneling is one of the bizarre constructs of quantum theory.

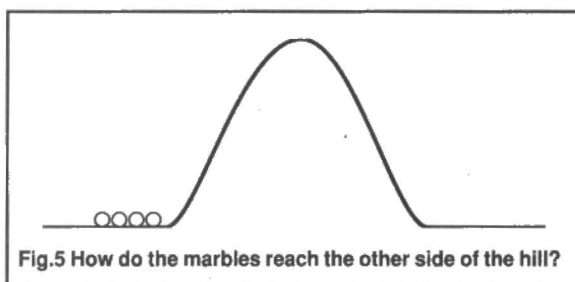
In Figure 5 we have a hill. On one side of the hill are some marbles. Now suppose you flick one of the marbles up the hill. As the marble goes up the hill it loses kinetic energy, coming down the other side it gets it back again, so at the

moment of arriving it should have exactly the same energy as at the moment it was flicked. The same kinetic energy because the speed lost on the way up the hill is regained

on the way down; the same potential energy because it rests at the same level as when it started.

So far classical physics and the quantum variety are in agreement. Where they differ is that quantum physics says there's no need for the flick. If the resting places on either side of the hill represent states of equal energy, as they do, there is a certain probability that a marble on one side of the hill will find itself on the opposite side without ever having the energy to go over the top. The barrier that charge carriers pass is not a physical one - the hill simply represents an

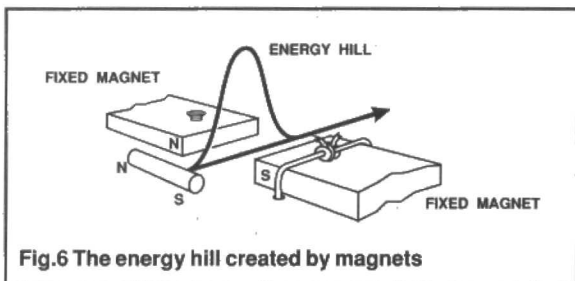
**Fig.4 The basic structure of an avalanche oscillator diode**



**Fig.5 How do the marbles reach the other side of the hill?**

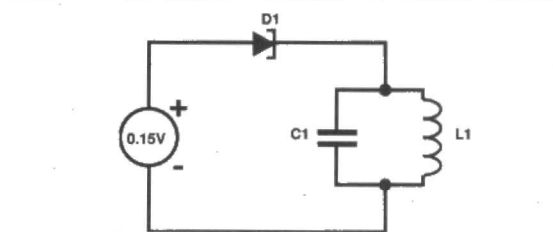
obstacle which needs a certain energy, according to classical physics, to pass. A better analogy might be the magnets in Figure 6. Roll the magnet slowly and it will be repelled by the fixed magnets. It needs a certain kind of kinetic energy to overcome the repulsion, so there is a kind of energy 'hill' that it has to pass.

The process of passing through an energy hill is known as tunneling. The one thing you mustn't ask is how the charge

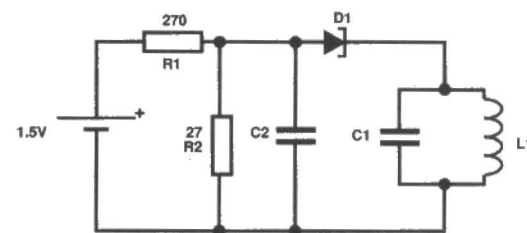


**Fig.6 The energy hill created by magnets**

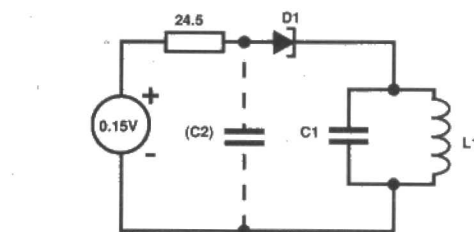
carriers do it: all that quantum physics has to say on the matter is that there's a certain probability that they will. If you feel skeptical about all this, you're in good company: it was the insistence of certain physicists that the deepest structures underlying our universe are, in a very real sense, statistical in nature which gave rise to Einstein's incredulous 'God does



**Fig.7a The bare bones of a tunnel diode oscillator**



**Fig.7b The practical circuit**



**Fig.7c The effective series resistance from the bias resistors, showing the need for C2**

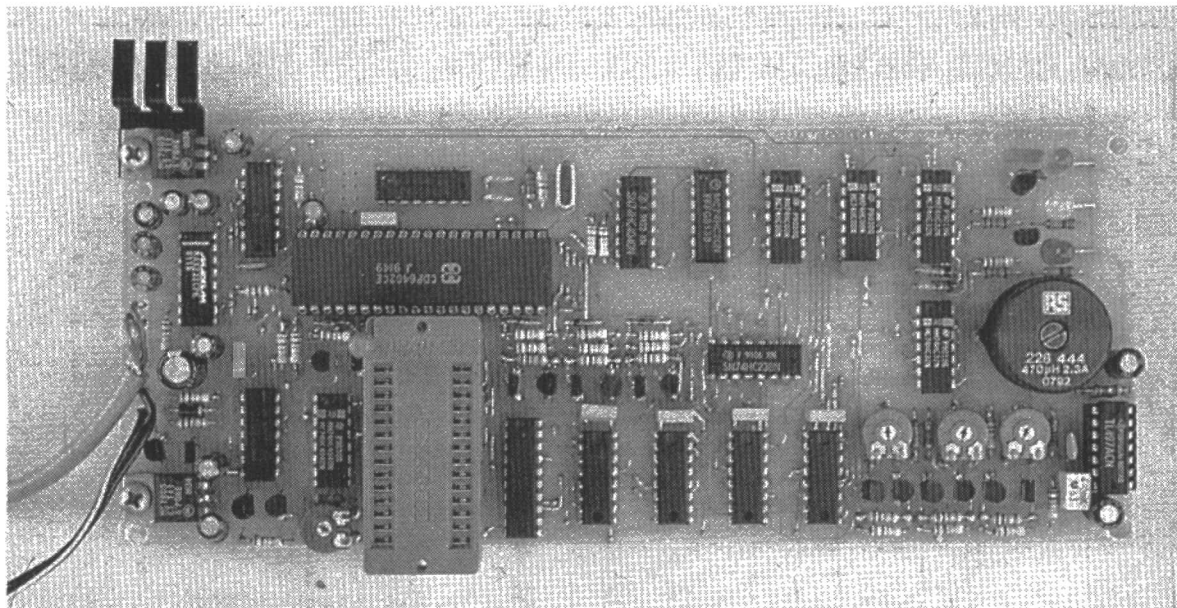
not play dice.' What was once a daring heresy is now the official doctrine!

As simple engineering bods who like nothing better than to solder a circuit or two, we needn't concern ourselves too much with the physics. The static characteristic of a tunnel diode (Figure 6) tells us all we need to know. The forward characteristic is similar to that of an ordinary diode, except for the all important hump at about 0.1V. And the really exciting portion of the hump is the downward slope between about 0.1V and 0.2V - here an increase in voltage causes a decrease in current, so the diode appears to have a negative resistance.

The basic-idea of a tunnel diode is shown in Figure 7a. The 0.15V supply biases the diode to the centre of its negative resistance region. A rise in voltage across the tuned circuit L1/C1 will give a corresponding reduction in the voltage across D1 which, because of its negative resistance, will cause an increase in the current through it. The extra current supplied to the tuned circuit is therefore in phase with the voltage across it, which is exactly what it needs to keep it oscillating.

A more practical version of the oscillator is shown in Figure 7b. Here R1 and R2 serve to 'pot down' the 1.5V supply to give the diode its bias voltage. C2 is included to reduce the impedance of the supply at the operating frequency - without it, the equivalent circuit of the bias supply is as shown in Figure 7c: the diode has a positive resistance in series with it which cancels out part of its negative resistance.

And that, I'm afraid, is your lot. If you're wondering why I haven't explained how diodes can be used for switching, or any of my other omissions, the reason is I didn't realize just how much you could do with a diode until I got started. In the words of the cordon bleu master chef, a diode is as versatile as ...a banana.



# EPROM Programmer

2

**Paul Stenning  
continues with his  
excellent design of  
EPROM programmer.**

**T**he construction of this PCB is rather fiddly and great care should be taken. All the components except the power input socket (SK2) and the RS232 socket (SK3) are mounted on the PCB. This is a double sided board, about 210x88mm in size, which is available from the ETI PCB service. Note that the holes in the PCB are not plated through. The PCB overlay is shown in Figure 6. Due to the complexity of the PCB, the construction should be carried out in the following order.

Firstly enlarge IC20 and IC21 mounting tab holes, L1 mounting hole and the corner fixing holes to 3mm. Also enlarge the holes for presets RV1-4 to 1.2mm, and the holes for IC20, IC21, D11 and the Veropins to 1.0mm

Next fit the through-board connections in the positions marked with a single small circle on the overlay, there are 122 in total. Tinned copper wire should be used here, suitable pins may be available but check they will fit the holes in the PCB (0.8mm) before ordering. Now fit the transistors, resistor network and non-polarised capacitors. The resistor network must be fitted the correct way round as shown on the overlay. Note that many of the component leads will also need to be soldered on the top of the PCB - wherever there is a pad it should be soldered to. This also applies to the resistors, diodes and presets which can now be fitted. Note that the presets can be fitted on the back of the PCB if required, this may ease adjustment once the PCB is mounted in the case.

Next fit all the DIL IC's except IC3 and IC19. Note that since many connections need to be soldered on the top of the PCB it is not possible to use conventional IC sockets, although some of the more expensive turned pin types may be

suitable. IC sockets should now be fitted in positions IC3, IC19 and SK1.

It is now possible to fit the remaining components in any convenient order. Temporarily solder the LEDs at the full length of their leads, and adjust them later when the PCB is being fitted in the case. L1 should be mounted with an M3 nut, bolt and shake-proof washer (do not over-tighten) or a dab of glue. IC20 and IC21 should be mounted with M3 nuts and bolts, IC21 would benefit from a small heatsink or bracket of some sort. Veropins should be fitted for the off-board connections. Fit a wire link in LK1 position, between the lower two homes for 9600 baud, or as shown on the overlay for other rates.

## Testing

The PCB should be tested before fitting into the case. Do not fit IC3 or IC19 yet. Connect the unit to a power supply via a test meter set to 500mA DC or greater. Switch on and watch the meter, if the reading exceeds 200mA switch off immediately and find out why! Make a note of this current. If all is well remove the meter and connect the power directly. Now set the meter to 10V DC or thereabouts and check  $V_{cc}$  on the power pins of one of the TTL IC's, this should be between 4.75V and 5.25V. Also check for about +9V on pin 2 of IC1 and about -9V on pin 6 of IC1.

If you have a 'scope, look at the DC input and check that the troughs of any ripple do not go below 10V. If there is significant ripple from the power supply (greater than about 1V pk-pk), try connecting a 1000µ/25V capacitor directly across the DC input.

You could now fit the remaining ICs, adjust the voltages, and try the unit in use - and probably get away with it! However I would strongly urge that the following step-by-step checks are carried out to ensure the unit is fully functional. A 'scope or logic probe would be most useful, although most of the checks can be done with just a test meter.

PROJECT

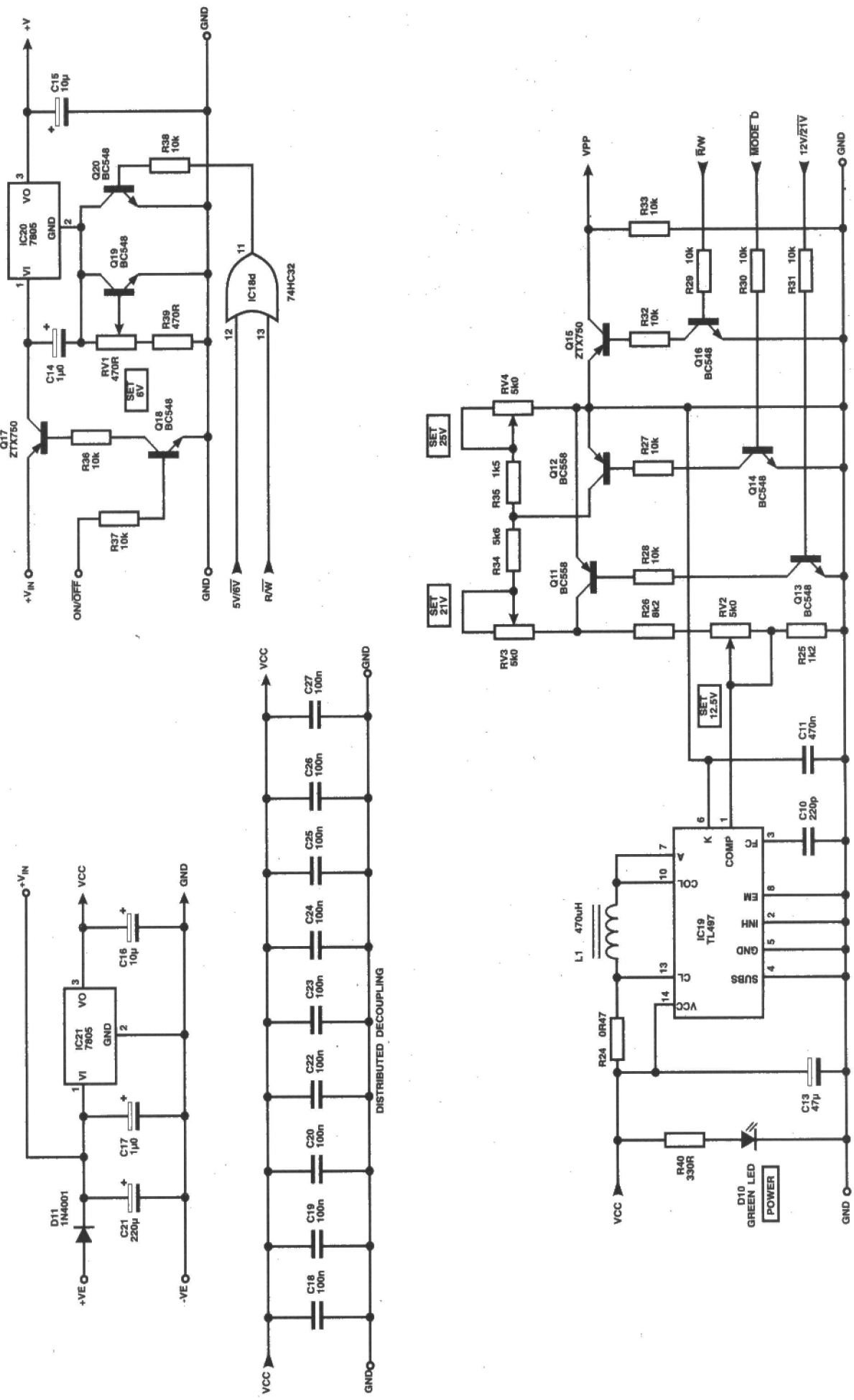


Fig.4 EPROM Programmer Power supplies

If you have an IBM PC or compatible, start BASICA or G.W.BASIC (or QBASIC if you have MS-DOS 5), and enter the test program given in Listing 1 (if you have obtained the disk from the author simply run TEST1.EXE, which is the compiled version). If you have a different computer you may have to modify or re-write the program as necessary, the notes in the 'How it Works - Software' section may be of some help. It may be worth trying to get access to a PC, to avoid having too many unknowns!

```

10 REM *** EPROM Programmer BASICA Test Program 1 Version 1.00
20 REM *** Copyright (C) Paul Stenning and ETI, 1992.
30 REM
40 SCREEN 0:CLS
50 PRINT "EPROM Programmer BASICA Test Program 1 - (C) Paul Stenning & ETI, 1992"
60 PRINT
70 OPEN "COM1:9600,N,8,1,CS200,CD0,DS0" FOR RANDOM AS #1 LEN = 1
80 INPUT AS$
90 IF AS$ = "" THEN PRINT "QUIT": CLOSE #1: END
100 IF LEN(AS) < 2 THEN PRINT TAB(10); "INPUT ERROR": GOTO 80
110 PRINT #1, CHR$(VAL("&H" + AS));
120 TIMEOUT = TIMER + 0.1
130 IF EOF(1) AND TIMER < TIMEOUT THEN GOTO 130
140 IF TIMER >= TIMEOUT THEN PRINT TAB(10); "": GOTO 80
150 AS$ = HEX$(ASC(INPUT$(1, #1)))
160 IF LEN(AS) < 2 THEN AS$ = "0" + AS$
170 PRINT TAB(10); AS$
180 GOTO 80

```

LISTING 1

Insert IC3 (the 6402), connect the programmer to the computers RS232 serial port (see Figure 5), switch it on and then run the software. The software does nothing more exciting than wait for you to enter a 2 digit hex number

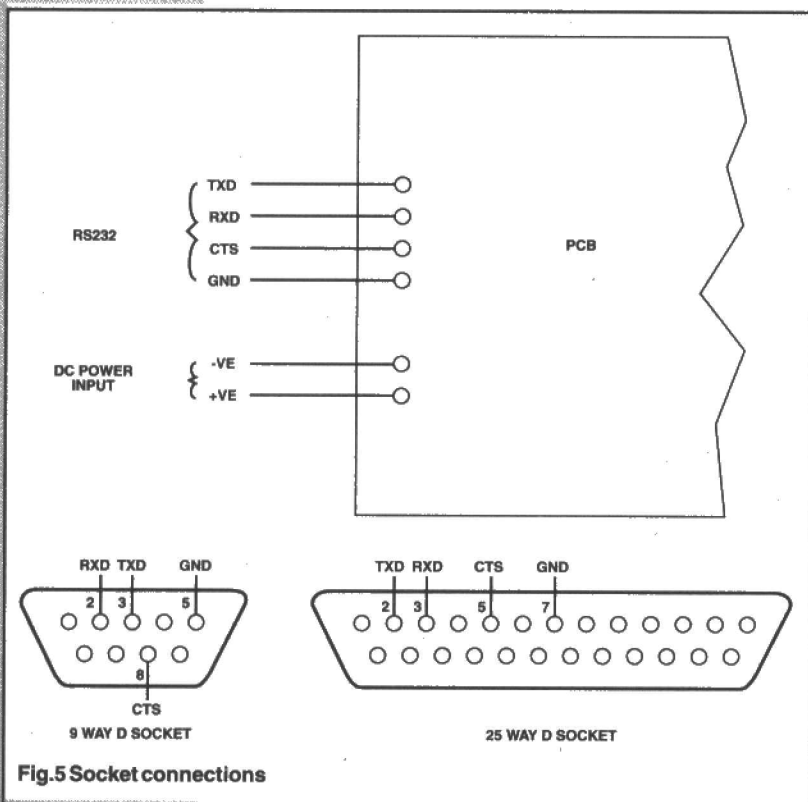


Fig.5 Socket connections

(followed by <Enter>) and then sends it to the programmer. It then attempts to read back a number, if it's successful it prints the number otherwise it prints \*\*. To exit just press <Enter> on it's own.

Type 'FF' (don't type the quotes, and follow it with <Enter>). Check the logic levels on pins 5 to 12 of IC3, they

should all be logic 1. Note that logic 1 is anything over 3.5V and logic 0 is anything under 0.5V. Now type '00' and the logic levels should all be 0. To be certain, type '55' and the levels should be 01010101, then type 'AA' and the levels should be 10101010. If you have a 'scope or logic probe check for a short positive going pulse on pin 19 whenever a number is sent.

```

10 REM *** EPROM Programmer BASICA Test Program 2 Version 1.00
20 REM *** Copyright (C) Paul Stenning and ETI, 1992.
30 REM
40 SCREEN 0:CLS
50 PRINT "EPROM Programmer BASICA Test Program 2 - (C) Paul Stenning & ETI, 1992"
60 PRINT
70 OPEN "COM1:9600,N,8,1,CS200,CD0,DS0" FOR RANDOM AS #1 LEN = 1
80 PRINT #1, CHR$(VAL("&h20"));
90 PRINT #1, CHR$(VAL("&h31"));
100 PRINT #1, CHR$(VAL("&h40"));
110 FOR COUNT = 0 TO 65535
120 LOCATE CSRLEN, 1: PRINT COUNT;
130 IF COUNT = 0 THEN GOSUB 210
140 IF COUNT = 21845 THEN GOSUB 210
150 IF COUNT = 43690 THEN GOSUB 210
160 IF COUNT = 65535 THEN GOSUB 210
170 PRINT #1, CHR$(VAL("&h50"));
180 IF INKEY$ = CHR$(27) THEN PRINT TAB(8); "ABORTED": GOTO 200
190 NEXT
200 CLOSE #1: END
210 PRINT TAB(8); "Press Any Key to Continue..."
220 IF INKEY$ = "" THEN GOTO 220
230 RETURN

```

LISTING 2

The most likely cause of problems here is the RS232 wiring. Are you using the right port (COM1) on your PC? You can edit line 70 of the program if you are using a port other than COM1. Have you set LK1 to 9600 (or lower if your type of computer won't work at 9600)? Try swapping wires 2 and 3 in the RS232 lead. If the program appears to lock try disconnecting the CTS wire (Ctrl-Break will stop the software in this case). Check the link settings on your serial communications port - if you have the 'Everex EV170 Magic I/O Card' (used in many early XT and 286 AT machines) and can't get it to work, write to the author!

Type '0F' and check pins 9, 10, 15 and 16 of IC6, they should all be at logic 1. Now type '00' and they should all be at logic 0. Typing '05' should give 0101 and '0A' should give 1010. Now repeat the above, replacing the first character with a '1' and checking the levels on IC7, then '2' and IC8, and finally '3' and IC9.

Now type '00', '10', '30' then '70'. After you typed the '70' the screen should show '00', the others should have given '\*\*\*'. The 'Program' (red) LED should also be on. This set '00' on the data bus, selected write mode to enable U10, then read the data back down the RS232 link. The most likely cause of problems here is the RS232 link again.

Now type '31' then '70'. The screen should show 'FF' and the 'Read' (yellow) LED should be on. IC10 is now disabled so it's outputs are tristate and pulled up by RN1.

Typing '30' then '70' should return '00' again. Typing '0F', '1F' then '70' should return 'FF', typing '05', '15' then '70' should give '55', and typing '0A', '1A' then '70' should give 'AA'. Also check that the appropriate data is actually reaching the EPROM socket pins as shown below:

Data Line Socket Pin	D7	D6	D5	D4	D3	D2	D1	D0
Type								
'00', '10'	0	0	0	0	0	0	0	0
'05', '15'	0	1	0	1	0	1	0	1
'0A', '1A'	1	0	1	0	1	0	1	0
'0F', '1F'	1	1	1	1	1	1	1	1

## HOW IT WORKS SOFTWARE

In the following section a reasonable understanding of programming in BASIC is assumed. The software was written for Microsoft BASICA, as supplied with Compaq DOS 3.31. It has also been tested with QBASIC supplied with MS-DOS 5 and with Microsoft QuickBASIC V4.5. Users of other BASIC dialects may have to modify the code to suit.

The first test program is shown in Listing 1. Line 70 opens COM1 (the first serial port) at <9600> Baud, <N> parity checking, <8> data bits, and <1> stop bit. The timeout on CTS (clear to send) is set to 200 milliseconds, CD (carrier detect) and DSR (data set ready) are disabled. Another serial port could be used in place of COM1 if required, by editing this line.

Line 80 accepts an input from the keyboard, the semicolon causes the cursor to remain on the same line after <Enter> is pressed. Line 90 terminates the program if no value is entered. Line 110 converts the entered data from a two character string to a single byte and sends it down the serial port. Note that in BASICA Hex numbers are indicated by preceding them with "&h", hence the value of "&hFF" is 255.

Lines 120 to 170 responsible for waiting up to 0.1 seconds for data to be sent back up the serial port and displaying it. TIMER is a BASICA variable which contains the number of seconds since midnight to 2 decimal places (updated 18.2 times per second), this is used in lines 120 and 130 to control the timeout. EOF(1) will have a value of 0 if data is present, otherwise it will be 1. Line 140 prints "\*" if a timeout has occurred, otherwise lines 150 to 170 read the value, convert it from a single byte to a two character string (using the HEX\$ function) and print it. Line 180 loops back round for another go!

The second test program, shown in Listing 2, is used to test the address counter system. This clears the counters and then repeatedly increments them, by sending the appropriate codes. The operation should be evident, given the information above.

The main control program is shown in Listing 3. This software is about the minimum required to make sensible use of the programmer. It is written in a manner which should make the functioning relatively easy to understand, and is not intended to be an example of good programming!

The subroutines at lines 7000 to 7060, and 8000 to 8020 fetch a byte from the serial port and send a byte to the serial port respectively. Their operation is as described in the Listing 1 details above. These subroutines are called frequently by the remainder of the program.

Line 100 opens the serial communications as before. Lines 120 to 300 attempt to establish communications with the programmer and test whether or not the CTS connection is present and working. Line 120 sets the program pulse duration to 40 milliseconds, initiates a program pulse immediately followed by a send instruction. If CTS is present the send instruction will not be sent until the program pulse has finished so data will be received, otherwise no data will be sent (see "How it Works - Hardware"). The integer variable PAUSE% is set to 1 if there is no CTS line, causing the software to add suitable delays itself - note that this will slow the operation of the software quite drastically.

Lines 150 to 280 send values to the data latches and then attempt to read them back - this is to establish that communication is reliable.

Lines 310 to 780 request information from the user regarding the EPROM type and programming requirements, whilst lines 790 to 820 set up the programmer accordingly.

Lines 1000 to 1230 form the main menu. Note that CHR\$(27) gives the value of the Escape key.

The Read, Program and Verify sections use ASCII-HEX data files in the programmers own format (conversion programs to and from Intel-HEX are given later). The format is easy to produce and edit manually.

The first line is the name of the EPROM type - "2716", "2732" etc. The remaining lines each start with the address in Hex (4 digits), followed by four spaces, followed by 16 bytes in Hex (2 digits) each separated by one space. The addresses must be sequential, starting at 0000. A small section is shown below:

2716	
0000	00 11 22 33 44 55 66 77 88 99 AA BB CC DD EE FF
0010	F0 23 DE F4 5A 22 3D 7E EA A2 C0 C0 38 24 AA 00
:	:
:	:
07E0	00 23 48 DE 4A D7 E1 4C 9A 8B BB DE 09 FF FF FF
07F0	FF FF FF FF FF FF FF FF FF FF FF FF FF FF FF

It should also be noted that this format is not particularly efficient with disk space - the file for a 27512 will take up about 250K. A file compression utility, such as PKZIP or LHARC, will dramatically reduce the size for storage if disk space is a problem.

With the information that has gone before, the operation of the remaining sections of the software should be fairly apparent.

The section from 2000 to 2300 reads the contents of the EPROM to a file. Lines 2100 and 2110 give a quarter second delay to allow the power supply rails to come up.

The section from 3000 to 3390 programs the EPROM from the contents of a file. Lines 3270 to 3290 add a delay (100 milliseconds) to allow for the programming pulse if the CTS line is not present, this will occur whether the programming pulse is 1 or 40 milliseconds. This delay may be optimised but it would be better to get CTS working in the first place.

The section from 4000 to 4330 verifies (or compares) the contents of the EPROM with a file, whilst the section from 5000 to 5240 checks the device is blank (all locations contain "FF"). The section from 6000 to 6220 allow the programming voltages to be checked.

Other programs are available to convert the EPROM programmer data files to and from standard Intel-HEX data files respectively. This is not the place for an explanation of the Intel-HEX file format, so please just accept that the programs work! Details of Intel-HEX and other standard file formats are on the disk available from the author, together with various conversion programs etc.

Now we come to the address bus. Type in the program given in Listing 2 (save the other program first as it will be needed again).

The program configures the programmer for 27512 EPROM's so all 16 address lines are bought to the EPROM socket and should be checked there. The program clears the address counter and then

repeatedly increments the count, pausing at selected points to enable the checks to be made, as shown below:

Addr Line	A15	A14	A13	A12	A11	A10	A9	A8	A7	A6	A5	A4	A3	A2	A1	A0
Socket Pin	1	27	26	2	23	21	24	25	3	4	5	6	7	8	9	10
Count	Expected Logic Level															
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21845	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1
43690	1	0	1	0	1	0	1	0	1	0	1	0	1	0	1	0
65535	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

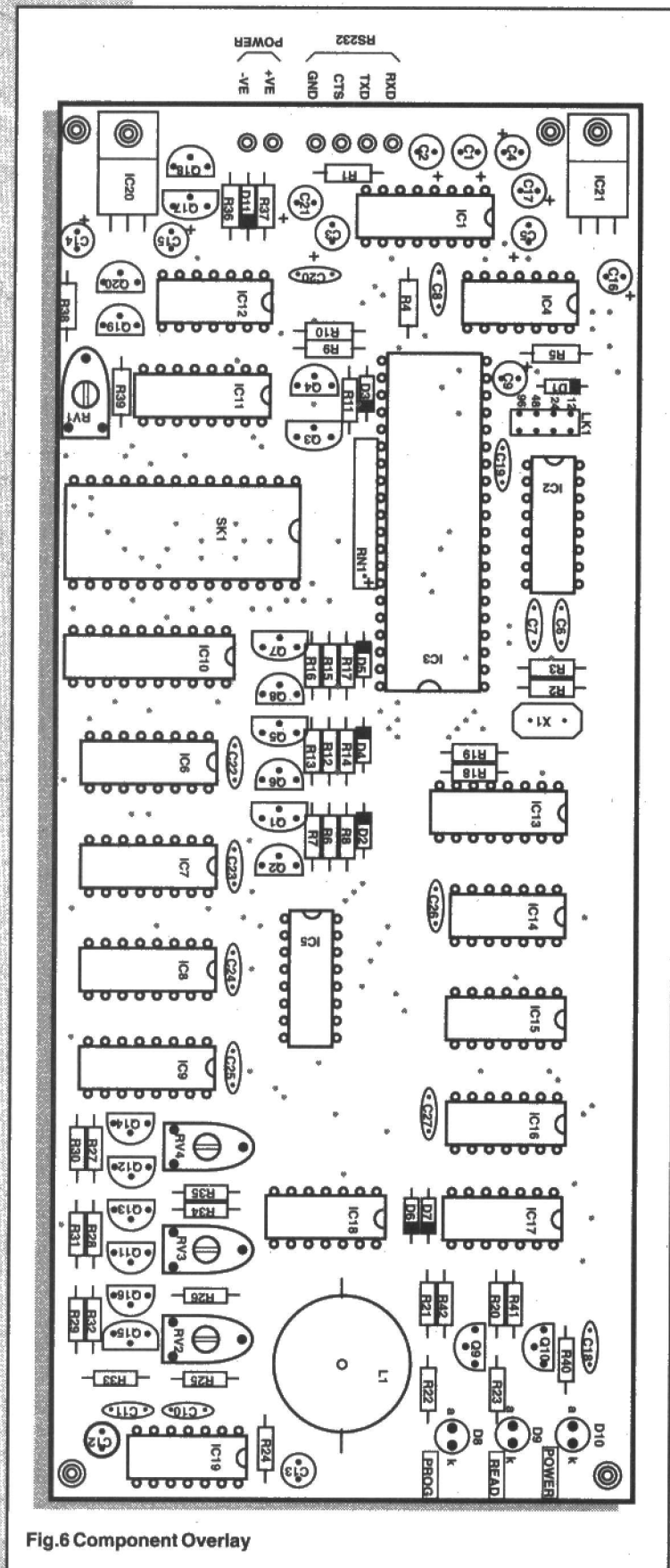


Fig.6 Component Overlay

The logic levels should be checked on the pins of the EPROM socket when the program pauses, if a level is incorrect check on the appropriate pin on IC11 or IC12, then trace the fault as necessary. Note that the program may run quite slowly. A compiled version (TEST2.EXE) which runs considerably faster is on the disk available from the author.

Now re-load the first test program. Connect a 'scope or logic probe to IC15 pin 11. Type '30'. Now when you type '60' you should observe a 40 millisecond positive going pulse. Move the probe to pin 8 of IC15 and the pulse should be negative going. Now type '32' and repeat the above checks, the pulse should now be 1 millisecond. With a logic probe you will probably only be able to detect the presence of the pulse and will have to assume it is the correct length, with a test meter you probably won't be able to see anything!

Now switch off and insert IC19. Connect a test meter set to about 500mA DC in line with the power input and switch back on. If the current is more than 100mA greater than it was before switch off and find out why! The most likely cause is a short circuit on VPP somewhere. If all is well remove the meter and connect the power directly. Set all four presets to the centre position.

Set a test meter to the 10V DC range and connect between pins 28 (+ve) and 14 (-ve) of the EPROM socket. Type '23' then '38', the meter should read 5V +/-0.25V. Now type '30' and the reading should rise, adjust RV1 for a reading of 6.1V +/-0.1V. Type '80' and the voltage should drop to zero. Set the meter to the 30V DC range and transfer the +ve meter probe to pin 1 of the EPROM socket. Type '34' and then adjust RV2 for a reading of 12.6V +/-0.1V. Type '30' and adjust RV3 for 21V +/-0.25V. Type '2F' and adjust RV4 for 25V +/-0.25V. Type '31' and the voltage should drop to zero.

The only thing left to check now is the various configurations for the different types of EPROM's. As described in 'How it Works', the functions of six of the EPROM socket pins vary depending upon the type of EPROM. The address lines have already been checked at the EPROM socket, as has the programming voltage to pin 1. The checking of the remaining combinations is detailed below.

Type '40' to clear the address counters. Connect a 'scope or logic probe to pin 20 of the EPROM socket. Type '30' then '2F'. A 40 millisecond positive going pulse should be observed when '60' is typed. Type '20', and the pulse when typing '60' should now be negative going. Now type '23' and the line should remain at logic 0 when '60' is typed. Move the probe to pin 22. Type '2F' then '31' and the line should be at logic 0. Type '30' and it should go to logic 1. Now type '20' and it should rise to 21V. Move the probe to pin 23 which should be at logic 0. Type '2F' and the line should rise to 25V. Move the probe to pin 26, which should be at 6V. Type '20' and it should go to logic 0. Finally move the probe to pin 27 and type '23'. A 40 millisecond negative going pulse should be seen when you type '60'.

If you have reached the end of all this successfully you can be confident that your EPROM programmer is 100% functional!

## The Case.

The prototype was mounted in a plastic case (type MB6) having external dimensions of 220x150x64mm. The removable panel is considered to be the bottom, and may be fitted with self-adhesive feet if required. The top surface needs cut-outs for the EPROM ZIF (Zero Insertion Force) socket and the LEDs, as well as four fixing holes for the PCB. You may also wish to make four small holes to enable adjustment of the presets.

The rectangular cut-out for the ZIF socket may be made by drilling a line of small holes around the edge then breaking out the centre part and filing to shape. Take care not to file

the hole too large or the result will look untidy! The socket is raised above the PCB by stacking up a number of 28 pin DIL IC sockets, three were used on the prototype. If the result feels insecure, the sockets may be held together with a suitable adhesive.

Position the PCB and mark the positions of the four fixing holes and then measure the positions of the three LED holes. The first LED is 4mm down and 6mm to the left of the top right fixing hole (view from outside the box), the other two are spaced below at 9mm intervals. The fixing holes are 3mm in diameter whilst the LED holes are 5mm. Also drill suitable holes in the rear of the case for the DC input socket and the RS232 cable or connector. On the prototype a 3.5mm jack socket was used for power (since this matched the plug on the PSU), and the RS232 cable passed through a hole fitted with a grommet. Choose connectors that are not likely to come unplugged accidentally! The case may now be marked with rub-down transfers or similar if required.

Solder suitable lengths of wire to the PCB for the off-board connections and insert the LEDs through the holes in the PCB (do not solder yet). Mount the PCB in the case using M3 screws, nuts and spacers, then position the LEDs so that they slightly protrude through the holes and solder them into place. Complete the interwiring (see Fig 5) and assemble the case. If an additional smoothing capacitor was found necessary whilst testing, this may be mounted across the pins of the DC input socket, or on the rear of the PCB in parallel with C21.

## In Use.

The control software is shown in Listing 3 and is suitable for an IBM PC or compatible machine running BASICA, G.W.BASIC or QBASIC. This software is about the minimum required to make sensible use of the programmer. The functioning of the software is described in the "How it Works - Software" section.

If BASICA or G.W.BASIC is being used, the program will run fairly slowly. This is a limitation of interpreted BASIC. QBASIC supplied with MS-DOS 5 is a much more advanced product and a good deal better in this respect.

Additional (faster) software is supplied on the disk available from the author, see Buylines.

An EPROM must not be inserted or removed if the 'Program' or 'Read' LED is lit, or if the programmer is configured for a different type of device. 24 pin EPROMs must be fitted in the lower pins (3-26) of the socket. In all cases pin 1 is upwards. Failure to observe the above may result in damage to the EPROM or (less likely) the programmer.

The programmer should be switched on and connected to COM1 (RS232 serial port 1) on the computer. Start the software and the 'Program' LED will light. Once successful communication has been established the program will request information about the type of EPROM and the programming method required. See the table below or consult the manufacturers data book.

Some 2764 and 27128 types require a complex arrangement of programming pulses however a single 1ms pulse will usually suffice. If in doubt or if problems are experienced use 40ms. Although some 2716 and 2732 devices will program successfully with a 1ms programming pulse, this is not recommended for final EPROMs, but may prove useful when testing software etc.

The use of the 'A' suffix on 12.5V 2764 and 27128 types appears to be less than standard, it is suggested that all 2764s and 27128s should be tried on 12.5V first, since 21V will destroy a 12.5V device.

Once these selections have been made the 'Program' LED will extinguish and the main menu will appear.

'Read' (menu option 1) reads the contents of an EPROM to a file. Note that the file format used is non-standard, however programs to convert to and from the Intel-HEX standard are available from the author (see buylines). The advantage of the file format is that it is easy to generate and edit manually.

'Program' (option 2) programs the EPROM from a file. The EPROM is not blank checked before programming or verified afterwards, these operations should be done from the main menu individually if required.

'Verify'

(option 3) compares the contents of the EPROM with a file, and 'Blank Check' (option 4) does as it's name suggests! Both

these options report the number of locations that failed.

'Change Configuration' (option 5) re-starts the software so the EPROM type and programming method can be changed.

'Adjust Voltages' (option 6) allows the programming voltages to be checked and adjusted if required.

Happy programming!

EPROM Type Number	Programming Voltage	Supply Voltage	Programming Pulse Length
2716 & 27C16	25V	5V	40ms
2732 & 27C32	21V	5V	40ms
2764	21V	5V	1ms
27C64 & 2764A	12.5V	5V	1ms
27128	21V	5V	1ms
27C128 & 27128A	12.5V	5V	1ms
27256 & 27C256	12.5V	6V	1ms
27512 & 27C512	12.5V	6V	1ms

## LISTING 3

```

10 REM *** EPROM Programmer BASICA Control Software Version 1.00
20 REM *** Copyright (C) Paul Stenning and ETI, 1992.
30 REM
40 SCREEN 0:CLS
50 PRINT "EPROM Programmer BASICA Control Software - (C) Paul Stenning & ETI, 1992"
60 PRINT:PRINT "Ensure EPROM Socket is Empty, then press any key..."
70 K$=INKEY$:IF K$="" THEN GOTO 70
80 IF K$=CHR$(27) THEN PRINT:PRINT "Quit":GOTO 10000
90 PRINT "Establishing Communication";
100 OPEN "COM1:9600,N,8,1,CS200,CD0,DS0" FOR RANDOM AS #1 LEN=1
110 PRINT:;
120 S$="30":GOSUB 8000:S$="80":GOSUB 8000:S$="70":GOSUB 8000:GOSUB 7000
130 IF F$="" THEN PAUSE%=1 ELSE PAUSE%=0
140 PRINT:;
150 S$="05":GOSUB 8000:S$="15":GOSUB 8000:S$="60":GOSUB 8000
160 IF PAUSE%=0 THEN GOTO 190
170 TIME=TIMER+0.1
180 IF TIMER<TIME GOTO 180
190 S$="70":GOSUB 8000
200 GOSUB 7000
210 IF F$=>"55" THEN GOTO 9000
220 PRINT:;
230 S$="0A":GOSUB 8000:S$="1A":GOSUB 8000:S$="60":GOSUB 8000
240 IF PAUSE%=0 THEN GOTO 270
250 TIME=TIMER+0.1
260 IF TIMER<TIME GOTO 260
270 S$="70":GOSUB 8000:GOSUB 7000
280 IF F$=>"AA" THEN GOTO 9000
290 PRINT:;
300 IF PAUSE%=0 THEN PRINT "Ok." ELSE PRINT "No CTS Line-Software Delay Used."
310 PRINT
320 PRINT " 1 - 2716"

```

```

330 PRINT " 2 - 2732"
340 PRINT " 3 - 2764"
350 PRINT " 4 - 27128"
360 PRINT " 5 - 27256"
370 PRINT " 6 - 27512"
380 PRINT "Select EPROM Type: ";
390 K$ = INKEY$
400 IF K$ = CHR$(27) THEN PRINT "Quit": GOTO 10000
410 IF K$ = "1" THEN TYPENAMES$ = "2716": TYPECODE$ = "2F": MAXADDR = 2047: GOTO 480
420 IF K$ = "2" THEN TYPENAMES$ = "2732": TYPECODE$ = "25": MAXADDR = 4095: GOTO 480
430 IF K$ = "3" THEN TYPENAMES$ = "2764": TYPECODE$ = "23": MAXADDR = 8191: GOTO 480
440 IF K$ = "4" THEN TYPENAMES$ = "27128": TYPECODE$ = "23": MAXADDR = 16383: GOTO 480
450 IF K$ = "5" THEN TYPENAMES$ = "27256": TYPECODE$ = "21": MAXADDR = 32767: GOTO 480
460 IF K$ = "6" THEN TYPENAMES$ = "27512": TYPECODE$ = "20": MAXADDR = 65535: GOTO 480
470 GOTO 390
480 PRINT TYPENAMES$
490 PRINT
500 PRINT " 1 - 12.5 Volts"
510 PRINT " 2 - 21/25 Volts"
520 PRINT "Select EPROM Programming Voltage: ";
530 K$ = INKEY$
540 IF K$ = CHR$(27) THEN PRINT "Quit": GOTO 10000
550 IF K$ = "1" THEN PROGVLTNAMES$ = "12.5 Volts": STATUS% = 4: GOTO 580
560 IF K$ = "2" THEN PROGVLTNAMES$ = "21/25 Volts": STATUS% = 0: GOTO 580
570 GOTO 530
580 PRINT PROGVLTNAMES$
590 PRINT
600 PRINT " 1 - 5 Volts"
610 PRINT " 2 - 6 Volts"
620 PRINT "Select EPROM Supply Voltage: ";
630 K$ = INKEY$
640 IF K$ = CHR$(27) THEN PRINT "Quit": GOTO 10000
650 IF K$ = "1" THEN SUPPVOLTNAMES$ = "5 Volts": STATUS% = STATUS% + 8: GOTO 680
660 IF K$ = "2" THEN SUPPVOLTNAMES$ = "6 Volts": STATUS% = STATUS% + 0: GOTO 680
670 GOTO 630
680 PRINT SUPPVOLTNAMES$
690 PRINT
700 PRINT " 1 - 1 MilliSecond"
710 PRINT " 2 - 40 MilliSeconds"
720 PRINT "Select EPROM Program Pulse Duration: ";
730 K$ = INKEY$
740 IF K$ = CHR$(27) THEN PRINT "Quit": GOTO 10000
750 IF K$ = "1" THEN PROGULSENAME$ = "1 MilliSecond": STATUS% = STATUS% + 2: GOTO 780
760 IF K$ = "2" THEN PROGULSENAME$ = "40 MilliSeconds": STATUS% = STATUS% + 0: GOTO 780
770 GOTO 730
780 PRINT PROGULSENAME$;
790 S$ = TYPECODE$: GOSUB 8000
800 S$ = "3" + HEX$(STATUS% + 1): GOSUB 8000
810 S$ = "00": GOSUB 8000: S$ = "10": GOSUB 8000
820 S$ = "40": GOSUB 8000: S$ = "80": GOSUB 8000

1000 REM *** Main Menu
1010 CLS
1020 PRINT "EPROM Programmer BASICA Control Software - (C) Paul Stenning & ETI, 1992"
1030 PRINT "Type "; TYPENAMES$; " Program "; PROGVLTNAMES$;
1040 PRINT " Supply "; SUPPVOLTNAMES$; " Pulse "; PROGULSENAME$
1050 PRINT: PRINT "MAIN MENU"
1060 PRINT "-----"
1070 PRINT " 1 - Read"
1080 PRINT " 2 - Program"
1090 PRINT " 3 - Verify"
1100 PRINT " 4 - Blank Check"
1110 PRINT " 5 - Change Configuration"
1120 PRINT " 6 - Adjust Voltages"
1130 PRINT "ESC - Quit"
1140 PRINT: PRINT "Select Option Required: ";
1150 K$ = INKEY$
1160 IF K$ = "1" THEN PRINT "Read": GOTO 2000
1170 IF K$ = "2" THEN PRINT "Program": GOTO 3000
1180 IF K$ = "3" THEN PRINT "Verify": GOTO 4000
1190 IF K$ = "4" THEN PRINT "Blank Check": GOTO 5000
1200 IF K$ = "5" THEN RUN
1210 IF K$ = "6" THEN PRINT "Adjust Voltages": GOTO 6000
1220 IF K$ = CHR$(27) THEN PRINT "Quit": GOTO 10000
1230 GOTO 1150

```

```

2000 REM *** Read EPROM to File
2010 PRINT: PRINT "Insert EPROM to Read, then press any key (ESC to Abort)"
2020 K$ = INKEY$: IF K$ = "" THEN GOTO 2020
2030 IF K$ = CHR$(27) THEN GOTO 1000
2040 PRINT
2050 INPUT "Output File Name "; FILE$

```

```

2060 OPEN FILE$ FOR OUTPUT AS #2
2070 PRINT
2080 PRINT #2, TYPENAMES$
2090 S$ = "40": GOSUB 8000
2100 TIME = TIMER + 0.25
2110 IF TIMER < TIME THEN GOTO 2110
2120 FOR ADDR = 0 TO (MAXADDR - 15) STEP 16
2130 IF INKEY$ = CHR$(27) THEN BEEP: PRINT: PRINT "ABORTED!": GOTO 2260
2140 ADDR$ = HEX$(ADDR)
2150 IF LEN(ADDR$) < 4 THEN ADDR$ = "0" + ADDR$: GOTO 2150
2160 PRINT #2, ADDR$: TAB(9);
2170 FOR COUNT% = 0 TO 15
2180 S$ = "70": GOSUB 8000: GOSUB 7000
2190 PRINT #2, F$, " ";
2200 S$ = "50": GOSUB 8000
2210 LOCATE CSRLIN, 1
2220 PRINT "Reading Location"; ADDR + COUNT%; "of"; MAXADDR;
2230 NEXT
2240 PRINT #2,
2250 NEXT
2260 S$ = "40": GOSUB 8000: S$ = "80": GOSUB 8000
2270 CLOSE #2
2280 PRINT: PRINT "Press any key to continue...";
2290 IF INKEY$ = "" THEN GOTO 2290
2300 GOTO 1000

```

```

3000 REM *** Program EPROM from File
3010 PRINT
3020 PRINT "Insert EPROM to Program, then press any key (ESC to Abort)"
3030 K$ = INKEY$: IF K$ = "" THEN GOTO 3030
3040 IF K$ = CHR$(27) THEN GOTO 1000
3050 PRINT
3060 INPUT "Input File Name "; FILE$
3070 OPEN FILE$ FOR INPUT AS #2
3080 LINE INPUT #2, DAT$
3090 IF DAT$ <> TYPENAMES$ THEN BEEP: PRINT "FILE DOES NOT MATCH EPROM TYPE":
GOTO 3340
3100 S$ = "3" + HEX$(STATUS%): GOSUB 8000
3110 S$ = "40": GOSUB 8000
3120 TIME = TIMER + 0.25
3130 IF TIMER < TIME THEN GOTO 3130
3140 PRINT
3150 FOR ADDR = 0 TO (MAXADDR - 15) STEP 16
3160 IF INKEY$ = CHR$(27) THEN BEEP: PRINT: PRINT "ABORTED!": GOTO 3340
3170 LINE INPUT #2, DAT$
3180 DAT = VAL("&h" + LEFT$(DAT$, 4))
3190 IF DAT < 0 THEN DAT = DAT + 65536
3200 IF DAT <> ADDR THEN BEEP: PRINT: PRINT "FILE ADDRESS ERROR": GOTO 3340
3210 FOR COUNT% = 0 TO 15
3220 LOCATE CSRLIN, 1
3230 PRINT "Programming Location"; ADDR + COUNT%; "of"; MAXADDR;
3240 S$ = "0" + MID$(DAT$, 10 + COUNT% * 3, 1): GOSUB 8000
3250 S$ = "1" + MID$(DAT$, 9 + COUNT% * 3, 1): GOSUB 8000
3260 S$ = "60": GOSUB 8000
3270 IF PAUSE% = 0 THEN GOTO 3300
3280 TIME = TIMER + 0.1
3290 IF TIMER < TIME THEN GOTO 3290
3300 S$ = "50": GOSUB 8000
3310 NEXT
3320 NEXT
3330 PRINT
3340 S$ = "3" + HEX$(STATUS% + 1): GOSUB 8000
3350 S$ = "40": GOSUB 8000: S$ = "80": GOSUB 8000
3360 CLOSE #2
3370 PRINT: PRINT "Press any key to continue...";
3380 IF INKEY$ = "" THEN GOTO 3380
3390 GOTO 1000

```

```

4000 REM *** Verify EPROM with File
4010 PRINT: PRINT "Insert EPROM to Verify, then press any key (ESC to Abort)"
4020 K$ = INKEY$: IF K$ = "" THEN GOTO 4020
4030 IF K$ = CHR$(27) THEN GOTO 1000
4040 PRINT: INPUT "Input File Name "; FILE$
4050 OPEN FILE$ FOR INPUT AS #2
4060 PRINT
4070 LINE INPUT #2, DAT$
4080 IF DAT$ <> TYPENAMES$ THEN BEEP: PRINT "FILE DOES NOT MATCH EPROM TYPE": GOTO
4300
4090 S$ = "40": GOSUB 8000
4100 TIME = TIMER + 0.25
4110 IF TIMER < TIME THEN GOTO 4110
4120 FAIL = 0
4130 FOR ADDR = 0 TO (MAXADDR - 15) STEP 16
4140 IF INKEY$ = CHR$(27) THEN BEEP: PRINT: PRINT "ABORTED!": GOTO 4300

```

```

4150 LINE INPUT #2, DAT$
4160 DAT = VAL("&h" + LEFT$(DAT$, 4))
4170 IF DAT < 0 THEN DAT = DAT + 65536
4180 IF DAT < ADDR THEN BEEP : PRINT "FILE ADDRESS ERROR" : GOTO 4300
4190 FOR COUNT% = 0 TO 15
4200 LOCATE CSRLIN, 1
4210 PRINT "Verifying Location"; ADDR + COUNT%; "of"; MAXADDR;
4220 S$ = "70" : GOSUB 8000 : GOSUB 7000
4230 IF F$ <> (MID$(DAT$, 9 + COUNT% * 3, 2)) THEN FAIL = FAIL + 1
4240 S$ = "50" : GOSUB 8000
4250 NEXT
4260 NEXT
4270 PRINT : PRINT
4280 IF FAIL = 0 THEN PRINT "Verified Ok"
4290 IF FAIL <> 0 THEN BEEP : PRINT "Verify Failed on"; FAIL; "Locations"
4300 S$ = "40" : GOSUB 8000 : S$ = "80" : GOSUB 8000
4310 CLOSE #2 : PRINT : PRINT "Press any key to continue...";
4320 IF INKEY$ = "" THEN GOTO 4320
4330 GOTO 1000

```

```

5000 REM *** Blank Check EPROM
5010 PRINT : PRINT "Insert EPROM to Blank Check, then press any key (ESC to Abort)"
5020 K$ = INKEY$ : IF K$ = "" THEN GOTO 5020
5030 IF K$ = CHR$(27) THEN GOTO 1000
5040 PRINT
5050 S$ = "40" : GOSUB 8000
5060 TIME = TIMER + 0.25
5070 IF TIMER < TIME THEN GOTO 5070
5080 FAIL = 0
5090 FOR ADDR = 0 TO MAXADDR
5100 LOCATE CSRLIN, 1
5110 PRINT "Checking Location"; ADDR; "of"; MAXADDR;
5120 S$ = "70" : GOSUB 8000 : S$ = "80" : GOSUB 8000
5130 GOSUB 7000
5140 IF F$ <> "FF" THEN FAIL = FAIL + 1
5150 S$ = "50" : GOSUB 8000
5160 IF INKEY$ = CHR$(27) THEN BEEP : PRINT "ABORTED" : GOTO 5210
5170 NEXT
5180 PRINT : PRINT
5190 IF FAIL = 0 THEN PRINT "Blank EPROM"
5200 IF FAIL <> 0 THEN BEEP : PRINT "EPROM NOT BLANK - Failed on"; FAIL; "Locations"
5210 S$ = "40" : GOSUB 8000 : S$ = "80" : GOSUB 8000
5220 PRINT : PRINT "Press any key to continue...";
5230 IF INKEY$ = "" THEN GOTO 5230
5240 GOTO 1000

```

```

6000 REM *** Adjust Programming Voltages
6010 PRINT : PRINT "Ensure EPROM Socket is Empty, then press any key (ESC to Abort)"
6020 K$ = INKEY$ : IF K$ = "" THEN GOTO 6020
6030 IF K$ = CHR$(27) THEN GOTO 1000
6040 PRINT
6050 S$ = "20" : GOSUB 8000 : S$ = "30" : GOSUB 8000
6060 PRINT "Connect Test Meter Between pins 28 (+ve) and 14 (-ve) of EPROM Socket"
6070 PRINT "Adjust RV1 for Reading of 6.1V (+/- 0.1V), then press any key..."
6080 IF INKEY$ = "" THEN GOTO 6080
6090 PRINT
6100 S$ = "21" : GOSUB 8000 : S$ = "34" : GOSUB 8000
6110 PRINT "Connect Test Meter Between pins 1 (+ve) and 14 (-ve) of EPROM Socket"
6120 PRINT "Adjust RV2 for Reading of 12.6V (+/- 0.1V), then press any key..."
6130 IF INKEY$ = "" THEN GOTO 6130
6140 S$ = "30" : GOSUB 8000
6150 PRINT "Adjust RV3 for Reading of 21V (+/- 0.25V), then press any key..."
6160 IF INKEY$ = "" THEN GOTO 6160
6170 S$ = "2F" : GOSUB 8000
6180 PRINT "Adjust RV4 for Reading of 25V (+/- 0.25V), then press any key...";
6190 IF INKEY$ = "" THEN GOTO 6190
6200 S$ = TYPECODE$ : GOSUB 8000 : S$ = "3" + HEX$(STATUS% + 1) : GOSUB 8000
6210 S$ = "80" : GOSUB 8000
6220 GOTO 1000

```

```

7000 REM *** Fetch Byte from Programmer
7010 TIMEOUT = TIMER + 0.1
7020 IF EOF(1) AND TIMER < TIMEOUT THEN GOTO 7020
7030 IF TIMER >= TIMEOUT THEN F$ = "" : RETURN
7040 F$ = HEX$(ASC(INPUT$(1, #1)))
7050 IF LEN(F$) < 2 THEN F$ = "0" + F$
7060 RETURN

```

```

8000 REM *** Send Byte to Programmer
8010 PRINT #1, CHR$(VAL("&h" + S$));
8020 RETURN

```

```

9000 REM *** Communication Error Message
9010 PRINT "ERROR COMMUNICATING WITH PROGRAMMER"
9020 BEEP
9030 GOTO 10000

```

```

10000 REM *** End Program
10010 CLOSE
10020 PRINT : PRINT
10030 SYSTEM

```

## BUYLINES

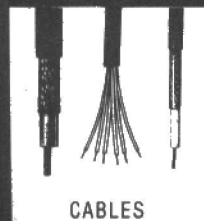
All components are available from Maplin, the majority can probably also be obtained from your usual supplier. Small 0.47R resistors do not appear to be readily available - use two 1R0 components in parallel. The PCB is available from the ETI PCB service. Before purchasing a power supply, check the latest bargain list from Greenweld (0703 236363), they often list suitable units for about £3.

The software listed in this article, together with a comprehensive menu driven control program and some useful bits and pieces (IBM PC or compatible only) is available from the author at the following address:

Paul Stenning, 1 Chisel Close, Hereford, HR4 9XF. Please send a blank PC formatted disk (3.5" or 5.25"), together with a cheque or postal order for £10, a return address label and adequate return postage (overseas 2 International Reply Coupons). If you do not have a disk send £12 and I will supply one (please specify size). B.A.E.C. members - see newsletter for a special offer!

The author would also be interested to hear from users of other computers, who have either written suitable control software or who are looking for some - he will attempt to put one in touch with the other! Please write with an SAE.

# Call us now! We have the widest range of components available - At competitive prices



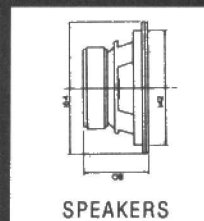
CABLES



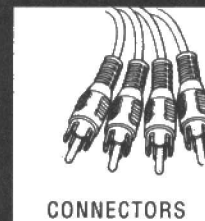
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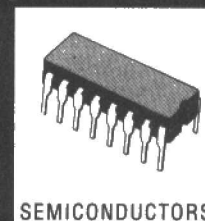
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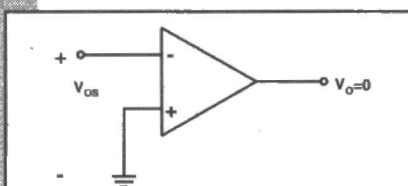
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# Choosing Operational Amplifiers

by Douglas Clarkson

**O**perational amplifiers can often present themselves like old familiar friends. Faced with a specific need in a specific design situation out will come the preference for a tried and tested solution. The array of choice in the field of operational amplifiers has never been greater. It is useful to examine some of the criteria which are appropriate for selection of operational amplifiers. It is also useful to review some of the specification terminology and compare a single factor across a range of devices.



**Fig.1** Origination of  $V_{os}$ , input offset voltage - the voltage which must be input to obtain 0 V at the output.

or automotive products are referenced. Differences can also arise due to varying power supply conditions, temperature and loading conditions. For data relating to specific devices the reader is recommended to consult specific data references.

Tables 1 & 2 indicate the range for values for a specific parameter for a variety of devices are. This gives a better 'feel' for how parameters can vary. Various parameters are interrelated as will be seen later.

## Packing Options

In terms of the packaging of operational amplifiers, the traditional dual in line packaging is still predominant although surface mount technology is being used increasingly in order to minimise board size. Surface mount devices appear to be more expensive than standard DIL versions.

## Input Offset Voltage

As indicated in Figure 1, this is the voltage which must be applied at the input to obtain zero output voltage.

Table 1 indicates that there is something like a ratio of 250:1 in the values of offset voltage that can be selected for devices. The ratio of (maximum/typical) values varies from about 2 to as much as 5.

## Input Offset Voltage Drift

Often a key factor in device design is the rate of change of  $V_{os}$  with temperature, eg. in low level signal amplification. Table 1 indicates a broad range in Input Offset Voltage drift values which reflects in general term the ranking in the table of  $V_{os}$  itself.

Calculated values of the percentage change in  $V_{os}$  as a function of a 10°C rise in temperature are shown in Table 1.

The LF411 seems to be particularly sensitive to temperature effects compared with average values of other devices.

## Input Bias Current

Although in the ideal case operational amplifiers are assumed to draw no current from the system they are connected to, a finite level of current does flow. Figure 2 shows currents  $I_1$  and  $I_2$  flowing into the device. The input bias current,  $I_b$ , is defined as:-

$$I_b = (I_1 + I_2)/2$$

Typical values are of the order of 50nA though values for JFET devices are considerably smaller. The significance of the size of the effect introduced due to bias current is largely determined by the circuit used with a specific circuit.

In the simple case of Figure 3, a simple inverting amplifier the total current flowing from input signal point V is determined by the impedance  $R_1$  so that:-

$$I = V/R_1 = I_b + I_g$$

where  $I_b$  is the bias current and  $I_g$  is the signal induced current flowing through the gain resistor. The 'loss' of signal at the output as a percentage of the total signal is:-

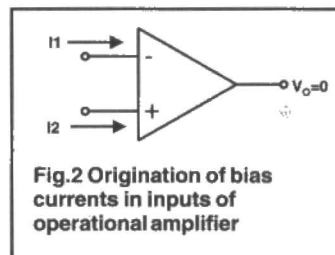
$$\frac{I_b \times 100}{(I_b + I_g)} = \frac{100}{(1 + I_g/I_b)}$$

The table below gives a summary of percentage loss as a function of ratio of  $I_g$  to  $I_b$

Ratio $I_g/I_b$	Percentage 'Loss' of signal
10	9.09
100	0.99
1000	0.0999
10,000	0.0099

**Percentage loss of signal with ratio of input currents to inverting amplifier for input bias current of 100nA**

Taking the example of a 100mV signal being amplified with an resistor  $R_1$  of 100,000k ohms to give 1000nA for  $I_g + I_b$ . Assuming a bias current of 100nA the ratio of currents is approximately 10 so a percentage loss of around 9% would be experienced. Thus working with low levels of input voltages and high input resistances in this amplifier configuration can significantly influence amplification characteristics.



**Fig.2** Origination of bias currents in inputs of operational amplifier

USE	DEVICE	MANUFACTURER	INPUT OFFSET mV		V <sub>os</sub> drift uV/C		% CHANGE V <sub>os</sub>		INPUT BIAS nA		INPUT OFFSET nA		GAIN	
			typ	max	typ	max	typ	max	typ	max	typ	max		
GEN PURPOSE QUAD	LM324	NAT	2	7	7	-	3.5	-	45	200	5	50	100V/mV	LS
GEN PURPOSE	LM741A	NAT	0.8	3	-	15	-	5	30	80	3	30	200V/mV	LS
PRECISION LOW NOISE	LH0044AC	NAT	0.008	0.025	0.1	0.5	12.5	20	8.5	15	1	2.5	145dB	OLG
JFET LOW OFFSET, LOW DRIFT	LF411A	NAT	0.3	0.5	7	10	23		0.05	0.2	0.025	0.1	200V/mV	LS
JFET INPUT	TL60CP	TEX	3	15	10	-	3.3		0.03	0.4	0.005	0.2	6V/mV	LS
JFET	TL80CP	TEX	3	15	10		3.3		0.03	0.4	0.005	0.2	200V/mV	LS
WIDEBAND JFET	LF351	NAT	5	10	10		2		0.05	0.2	0.025	0.1	100V/mV	LS
LINCMOS SINGLE	TLC2201CP	TEX	0.1	0.5	0.5		5		-	0.1	-	0.1	55V/mV	LS

Table 1 (OLG=OPEN LOOP GAIN)

There is therefore a considerable variation in the bias current performance - ratio of typically 1000:1 between the general purpose LM741A family type and a specialised JFET. Where operational amplifiers are working with low values of current signals, it is appropriate to use devices such as JFETs to minimise effect of bias currents.

### Input Offset Current

The input offset current is the difference between the inverting and the non-inverting bias currents:-

$$I_{os} = I_1 - I_2$$

Typical values of input offset current are of the order of 10 to 20nA with JFET devices having significantly smaller values around 0.1mA. Devices of higher specification have more closely matched bias currents and correspondingly low values of input offset current.

### Voltage Gain

The gain of an operational amplifier is the ratio of the output voltage magnitude to the input voltage magnitude. In specifications it is typically shown as V/V (output voltage change as a function of input voltage change) or as dB.

The voltage gain in dB is defined as:-

$$20 \log_{10} (V_o/V_i)$$

where  $V_o$  is output voltage and  $V_i$  is input voltage.

The table below indicates dB values for corresponding ratio values of voltage gain.

Voltage Ratio	db gain
100	40
1000	60
10000	80
100,000	100
1,000,000	120

The dB value is most frequently used in device specifications and is identified with the power gain of the specific device rather than the voltage amplification.

Thus where the output rises 1V for an input of 10 $\mu$ V, the operational amplifier will have a gain of 100,000.

The DC voltage gain of an operational amplifier is seldom a critical factor in operational amplifier selection. What is of more relevance is the open-loop gain as a function of frequency. The bandwidth is the frequency range for which the gain is within 3dB of its peak.

### Power Supply Rejection Ratio

This is the term which relates to the sensitivity of the input offset voltage to power supply voltage. It is defined as the ratio of the change in  $V_{os}$  to the total change in power supply voltage.

Thus for a supply change of 1 volt and a PSRR of 100dB, the change in  $V_{os}$  will be 10 $\mu$ V. It should be noted that if the power rails change from +6V and -6V to +5V and -5V, this is a change of 2V in the power supply for such calculations.

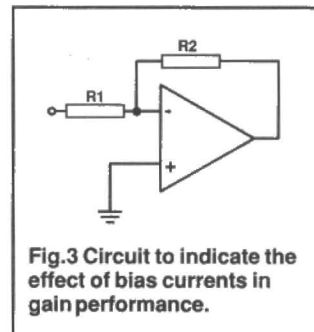


Fig.3 Circuit to indicate the effect of bias currents in gain performance.

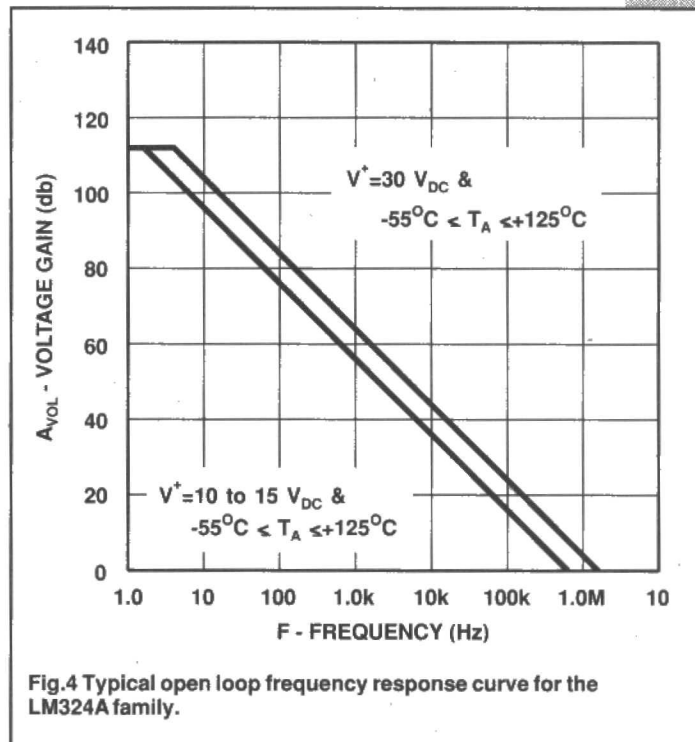


Fig.4 Typical open loop frequency response curve for the LM324A family.

It is appropriate that the precision low noise amplifier LH0044AC has a very high PSRR. Where, for example, a 1 volt change in supply level will produce 0.05 $\mu$ V change in  $V_{os}$ . This is consistent with the low value of 8 $\mu$ V of  $V_{os}$  for the LH0044AC device.

## Common Mode Rejection Ratio

The CMRR is the magnitude of the ratio of the change in  $V_{os}$  to the corresponding change in common mode voltage - the common voltage established across the inverting and non-inverting inputs.

It will be appreciated that CMRR is potentially more of a problem than PSRR in some devices in changing the effective value of  $V_{os}$  in a circuit. The LM324A, for example, has a

Data tends not to be provided for operation at these supply voltages so care is required in using operational amplifiers within these voltage rails. It would be a safe bet, however, to assume that a bipolar operational amplifier powered on  $\pm 5$  rails would not be able to be driven beyond  $\pm 3.5V$ . The TLC2201CP has a clear advantage of performing better in this voltage region.

USE	DEVICE	MANUFACTURER	PSRR (dB)	CMRR	SLEW RATE V/ $\mu$ s	SUPPLY CURRENT PER UNIT (mA)		VOLTAGE SWING		UNITY GAIN BANDWIDTH (MHz)	EQ INPUT NOISE VOLTAGE	COST £
			typ	typ	typ	typ	max	typ	max	typ	typ	
GEN PURPOSE QUAD	LM324	NAT	100	85		1.5	3	(28V at 30V)		1		0.35
GEN PURPOSE	LM741A	NAT	96	95	0.7	1.7	2.8	$\pm 12$	$\pm 14$	1.5		0.60
PRECISION LOW NOISE	LH0044AC	NAT	145	145	0.06	0.9	3.0	$\pm 13.7$		0.4	8 (1kHz)	26.00
JFET LOW OFFSET, LOW DRIFT	LF411A	NAT	100	100	15	1.8	2.8	$\pm 13.5$		4	25 (1kHz)	10.30
JFET INPUT	TL60CP	TEX	95	86	3.5	0.2	0.25	$\pm 13.5$		1	42 (1kHz)	0.60
JFET	TL80CP	TEX	86	86	13	1.4	2.8	$\pm 13.5$		3	18 (1kHz)	0.60
WIDEBAND JFET	LF351	NAT	100	100	13	1.8	3.4	$\pm 13.5$		4	25 (1kHz)	0.50
LINCOS SINGLE	TLC2201CP	TEX	110	110	2.5	1	1.5	$\pm 4.8$		1.8	8 (1kHz)	2.70

Table 2 (DATA CORRESPONDS TO  $\pm 15V$  SUPPLY UNLESS OTHERWISE STATED)

CMRR some 15dB worse than the PSRR. The trend of high CMRR of operational amplifiers which require to have low values of  $V_{os}$  is identified. This is a similar situation with specification of PSRR.

## Slew rate

This term describes the maximum change in output voltage that the operational amplifier can accommodate. It is usually expressed in V/ $\mu$ S.

Thus while the LH0044AC device is excellent at high gain operations on account of its low value of  $V_{os}$  and high CMRR and high PSRR, it would not be appropriate in a sample and hold application where voltage levels were being captured and held over short time intervals, eg 0.1 $\mu$ s.

## Supply Current

This is defined as the current which an operational amplifier will draw when there is no load current. This factor is of particular relevance in the design of battery equipment, where low power consumption is a key design criteria. The data presented relates to supply at  $\pm 15V$ .

It is also of relevance when power supply requirements are being determined where extensive linear devices are being used.

The TL60 range thus offers some advantages of lower power consumption. The LM324 is a four amplifier device.

## Output Voltage Swing

Problems can often arise in the design of circuits when eg. with a supply of 5V, a bipolar operational amplifier will develop a maximum positive voltage swing of 3.7V. The following table gives an indication of the ability of devices to function within the range of supply voltages provided.

Circuits are tending to be used with supply rails of  $\pm 5V$  in portable equipment in order to minimise current drain.

## Unity Gain Bandwidth

Figure 4 shows the typical Open loop frequency response curve for the LM324A family and Figure 5 the circuit used to determine the characteristic.

Table 2 shows that low cost devices such as TL80 range can have unity gain bandwidth products of around 3MHz.

## Noise Information

Data relative to noise is of importance where low level signals are being significantly amplified. Figure 6 shows the equivalent noise voltage as a function of frequency for the TL80 to TL85 range of devices. There is a rapid decline in noise signal with a plateau commencing at around 400Hz. Values quoted at 1kHz are therefore representative of the greater range of signals in the noise spectrum. The values quoted in Table 2 are nV/ (Hz).

Where data is not available eg for the LM324 and LM741A it may be taken that the values are higher than typically referenced for the other devices. The TL80 range would be of more use as pre amplifiers in audio circuits than the TL60 series. The TLC22001CP shows good low noise characteristics - on a par with the more expensive LH0044AC.

## Cost of Components

Table 2 summarises the approximate cost of the devices. The prices quoted indicate approximate prices and are for

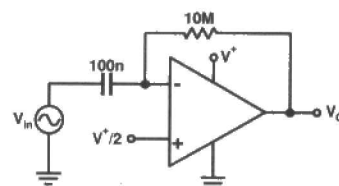


Fig.5 Circuit used to measure open loop frequency response indicated in Figure 4.

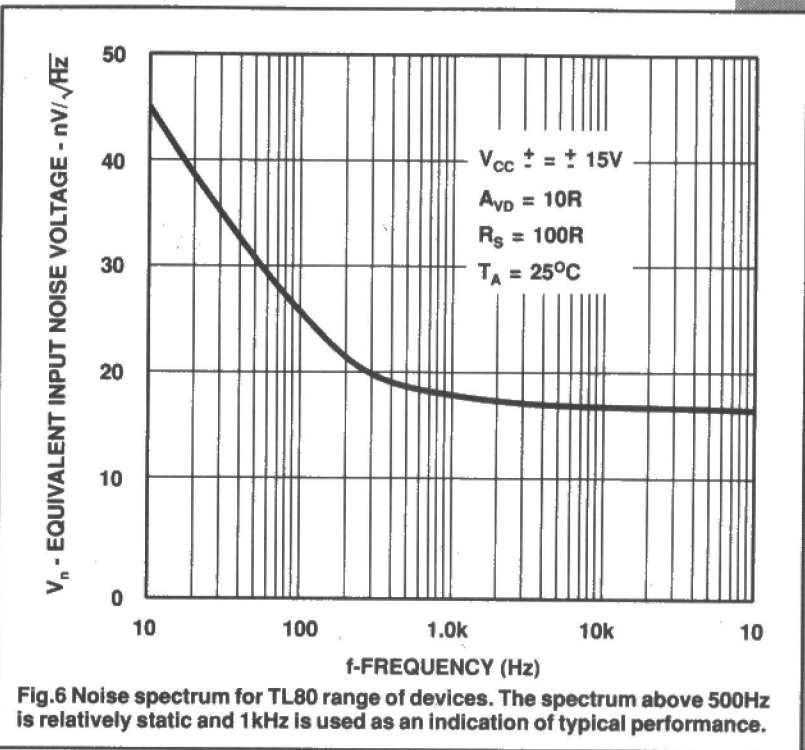
general indication only. Significant variations in price takes place as different specifications of the one device are quoted. Thus the top of the range LM324AM costs around £7.00 while the humble LM324N costs around £0.35. The variations within the TL60 range and the TL80 range are certainly not as extreme as with the LM324 package. Considering its good design properties and modest cost, the TLC2201CP device certainly comes out on top of the set reviewed here.

Points of Reflection

The needs of the designer will vary considerably depending on the task in hand. A key factor will perhaps be bandwidth, or low supply current or low noise. At a very basic level it may be price. It is surprising how much of mass produced electronics is down to price - to the last one penny.

In consumer products when customers are inspecting a sound system, they cannot know the noise spectrum of the input stage or be in any position to measure it. Appearances of the console and the LEDs on the front will carry more weight. Where there is a difference in 5p between two components and one has a higher specification, then invariably the cheaper component will be selected.

For the electronics designer, building and developing his own products in relation to his own understanding, then the



choice between a mediocre chip at £0.50 and a superior one at £2.50 is not difficult - he or she invariably choose the better device in order to put better value into the system.

It is perhaps appropriate to set out a table which will help the process of op amp selection. Each of the parameters is graded on a scale of 1 to 10, reflecting at 10 the best device. This is indicated in Table 4

This chart, therefore, serves to scale operational amplifiers on a scale of 1 to 10 on each parameter. By circling the values required for each parameter (if these are known) this will give a rough and ready assessment of the design requirements. If the electronic designer uses this template (copying it) to enter the details of a set of specific devices, he or she will soon see if the device is a close match to the required parameters.

In order to really understand the devices being worked with, it is essential to obtain appropriate linear data books. This is where education in linear electronics really begins.

INCREASING SCALE OF OP AMP PERFORMANCE										
POOREST	AVERAGE								BEST	
1	2	3	4	5	6	7	8	9	10	
10	5	3	2	1	0.5	0.2	0.05	0.02	0.01	Input Offset mV
30	25	20	15	10	7.5	2.5	1.0	0.5	0.1	Vos/C µV/C
400	200	100	75	50	25	10	1	0.1	0.03	input bias nA
20	15	10	7.5	5	1	0.2	0.05	0.01	0.005	input offset nA
1	2	10	50	100	110	120	140	170	200	gain V/µV
80	84	88	92	96	100	105	110	120	140	PSRR dB
75	80	84	88	92	96	100	104	114	134	CMRR dB
0.1	0.2	0.3	0.5	0.7	1.0	1.5	3.0	7.0	15	sl.r.V/µV
5.0	3.0	2.0	1.0	0.5	0.4	0.3	0.2	0.1	0.05	sup cur mA
0.2	0.3	0.5	0.7	1.0	2.0	3.0	5.0	10.0	20.0	UGB MHz
100	80	60	50	25	20	15	10	7.5	5.0	iv noise

where iv noise = input noise voltage nV/(Hz) at 1kHz sup cur = supply current per amplifier  
sl.r = slew rate

Table 4: Summary of grading between low performance and high performance parameters of operational amplifiers. Typical values are shown.

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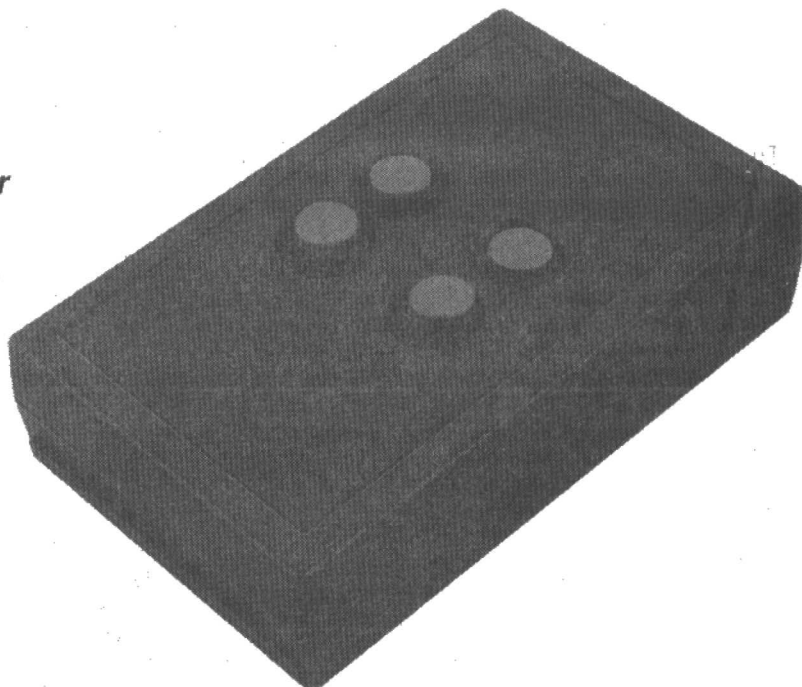
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An effective way to control and dim four sets of lights independently. Ken Blackwell now describes the transmitter.

2



# Four Channel Remote Control

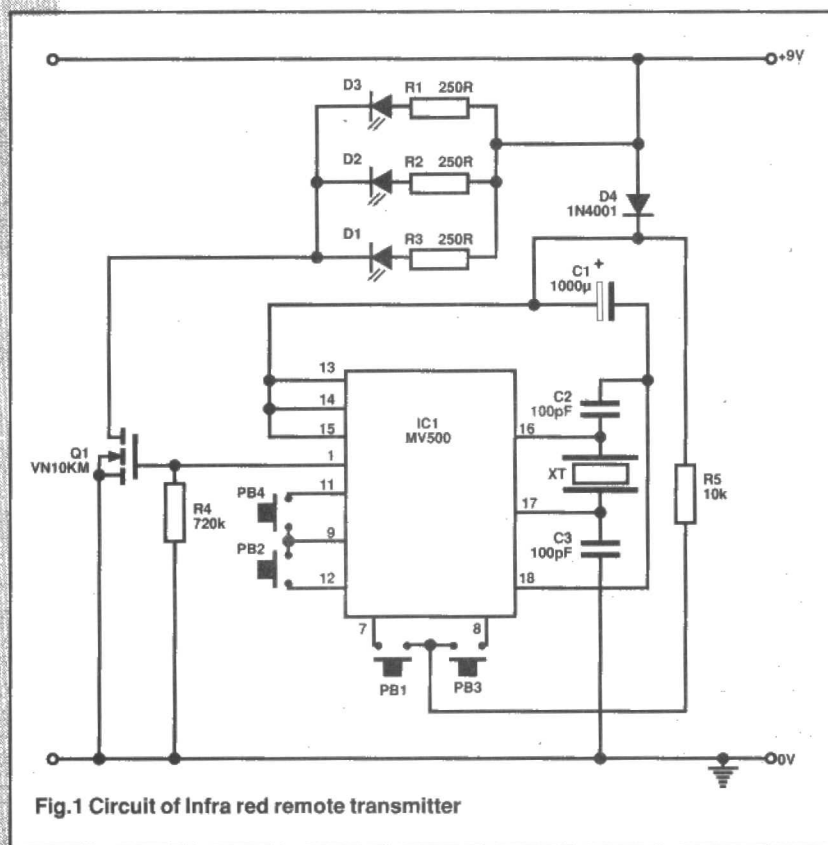


Fig.1 Circuit of Infra red remote transmitter

## HOW IT WORKS

### Transmitter Operation

No setting up is required. This IR Transmitter is pulse modulated to match the IR receiver controlling touch type dimmer switches. The coded outputs are digital ABCD only, set to momentary operate the receiver reed relay outputs. VMOS collects a positive supply through the 10hm resistors and the IR diodes then discharge to earth.

IC1 is a Plessey IR Encoder MV500 complementary to IR receiver Decoder MV601. A 9 volt PP3 battery is connected to diode D4. This diode gives protection through mis-connections and also charges the smoothing capacitor C1 to reduce the voltage drop that occurs during the high current discharge when transmitting, in effect giving the highest obtainable voltage to IC1 which in turn gives a high output pulse to pin 1 and the gate of Q1. XT1 is a 500kHz ceramic resonator connected to the two 100p to forms a Pierce circuit. This circuit is oscillating at the same rate as its complementary receiver circuit. When a push switch selection is made a pulsed output current is sent to Q1 gate causing a very high pulsed current to be passed through to ground via the resistors R1-3 and IR emitter diodes D1-3. R4 is included to bias the gate on Q1 to OFF by grounding. Output push switches connect a source to sink as configured, and R5 is included to limit a positive source current.

**P**redictably in the future, domestic remote controlled lighting and dimming will be as common as the television remote control and with the availability of multi programable transmitters on the market, eventually all domestic systems will be programmed into one master transmitter.

With mains lighting, the design criterion requires that the lighting system must not depend entirely on remote control. Manual switching is the most convenient simple method of switching, the remote operation is the added practical refinement of modern living, and probably only used during

relaxation times or as an aid to the unfortunate handicapped or bed-ridden patients. The greatest advantage is the means of controlling the dimming level of lighting from a position of relaxation.

In the case of the following Infra Red remote design any combination, MANUAL 'OR' REMOTE switching and dimming can be operated from each separate touch dimmer switch.

This remote system is coupled to control a suitable easily available touch dimmer switch, manufactured by Home Automation, but others would work on the same principle.

## In Operation

The circuit described is an infra red encoded system, configured to select four digital channel outputs. This allows a single output for each of the channels. By selecting one of the four push button switches an encoded pulsed infra-red output is sent from the infra-red diodes to the decoder on the receiver circuit, which in turn pulls in the selected reed relay. This transmitter circuit is pre set to match the complimentary encoder micro chip and no setting up is required.

The transmitter operates four channels and basically of standard construction, with a couple of selected components to give increased range.

The receiver described last month is mains powered and converted to give a DC supply output via a zener voltage of 15 volts at 35mA, then again regulated to supply various components with a smooth 5 volt supply. Detection of infra red pulses are pre amplified and filtered by the 'Tandy' IR

of components before soldering them in. The flats on the infra-red diodes indicate the ground side. Check for pairs of pins on the push buttons before soldering. Ensure the VMOS semiconductor is fitted as per diagrams for polarity. On completion, fit the heavy duty battery to the battery clip and press the push buttons. The circuit is designed to fit in the smallest of hand held plastic boxes readily available from many distributors and Tandy shops. The box has to be drilled to accommodate the infra-red diodes and push buttons.

... Stop Press ... Stop Press ... Stop Press ...

## WARNING

Some design elements of the Remote Controlled Receiver (Part 1) have been questioned. It is therefore strongly advised that the construction and operation is withheld until modifications are published in the March issue of ETI

# Control Dimmer

Detector unit, a hybrid receiver/demodulator. These output signals are transistor amplified and passed to the remote control receiver IC pin 1. With matching pulse position modulation, the momentary switch selected ABCD logic couples directly to one of four miniature 5V DC plug in reed relays. The normally open relay contacts, close, making an earth connection to the appropriate dimmer switch touch plate, completing the dimming/switching cycle.

## Transmitter Construction

The construction is very straight forward, soldering in the components as shown in the component overlay starting with the low components first like resistors. Do check the polarity

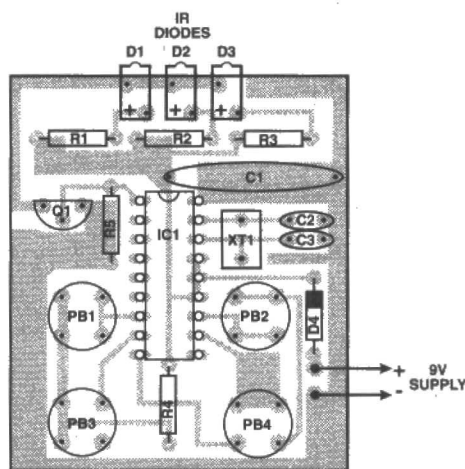


Fig.2 Component Overlay of transmitter

## PARTS LIST

### TRANSMITTER

#### RESISTORS

R1,2,3 1R  
R4 720k  
R5 10k

#### CAPACITORS

C1 1000u/10V  
C2,3 100p disc ceramic

#### SEMICONDUCTORS

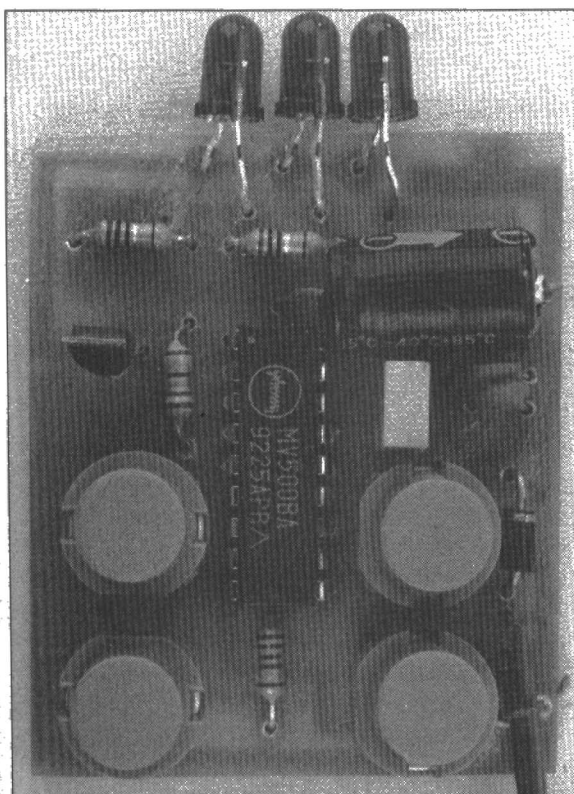
IC1 MV500 transmitter  
Q1 VN10KM  
D1,2,3 High power Infra-red emitters  
D4 1N4001

#### MISCELLANEOUS

PB1,2,3,4 Momentary push switches  
Pad Kit JY01B  
XT1 500kHz ceramic resonator  
PP3 Battery clip connector  
PP3 Battery  
Remote control housing

## BUYLINES

Most of the parts are available from Rapid Electronics. The Infra-red receiver module is from Tandy Stores. The choke is from Maplin (JL72P). The MV601, resonator and MV500 are available from Electromail. A kit of parts (excluding box and battery) for £25 is available from ADVF Service, 131 Aldermans Drive, Peterborough, Cambs PE3 6BB



# Microprocessor Sound to MIDI Convertor

*Let the musical instruments  
follow your lead with this  
MIDI project by Tom Scarff*

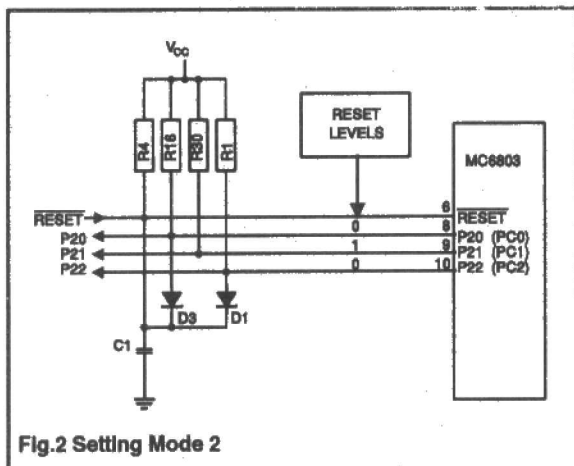
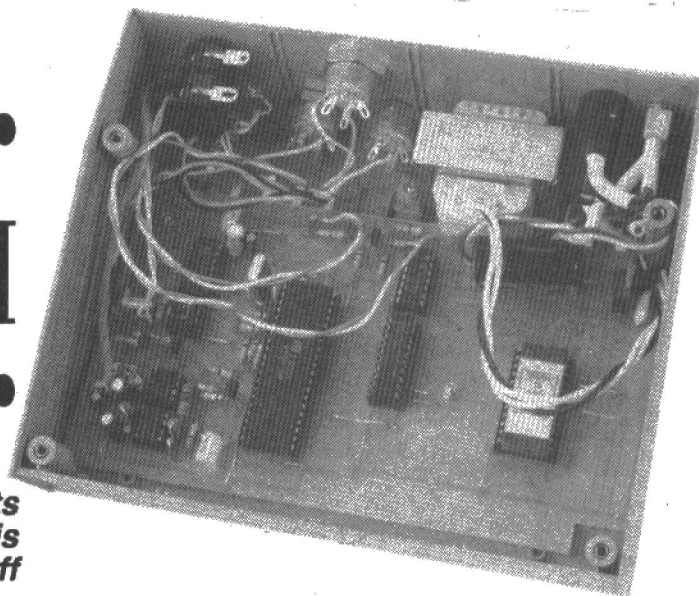


Fig.2 Setting Mode 2

**E**ver wanted to hum or whistle a tune and have a complete orchestral sound backing you? Well this project consists of the hardware and software to implement a sound to MIDI convertor which will allow the digital playing of MIDI data on a MIDI instrument controlled by any acoustic instrument or voice via a microphone, or by a guitar via an electromagnetic pick-up.

MIDI, as most people know by now, is the acronym for Musical Instrument Digital Interface and is at present the universal standard for connecting and controlling electronic musical instruments. Generally MIDI synthesisers are keyboard controlled but not all musicians are keyboard proficient and would still like access to the various MIDI synthesiser sound sources. In order to achieve this I designed a Sound to MIDI convertor which converts an incoming frequency to its equivalent MIDI note-on and note-off data.

MIDI data is transmitted or received as asynchronous serial data at a rate of 31.25K BAUD with a format of 1 start bit, 8 data bits, and 1 stop bit. The MIDI Out connection operates using a 5mA current loop.

## Digital Circuit

The circuit is designed around the 6803 microprocessor which contains 128 bytes of RAM, for the programme variables, a Serial Communications Interface, for interfacing to the MIDI in and out connectors, eight parallel input/output lines, with one input polled for start and end of a note, and a three function programmable timer, which is used to calculate the incoming frequency of a note.

An internal clock generator with a divide-by-four output is also present. The processor also allows the combination of two eight bit accumulators to provide operation of sixteen bit arithmetic. The NMOS 6803 CPU is also available cheaply and 6800 software has appeared in previous articles.

The operating mode of the 6803 is selected at power-on or reset by the voltage levels present on the Port 2 pins P20, P21 and P22. With the configuration shown in Figure 2 mode 2 is selected which makes use of the internal RAM and the multiplexed Data/Address bus.

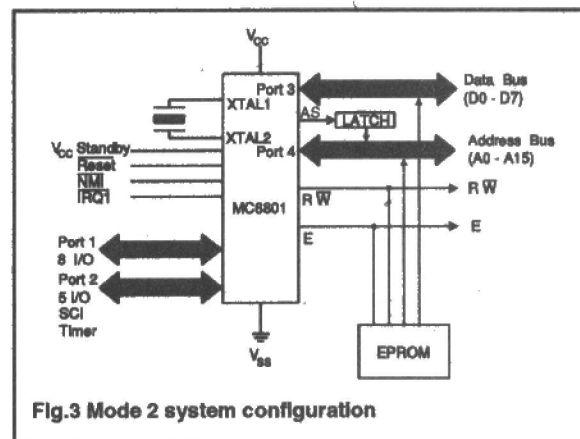


Fig.3 Mode 2 system configuration

The lower address byte has to be latched before feeding into the address bus as in Figure 3. An output signal, the Address Strobe (AS), is provided to enable the latches in IC5 at the correct instant in time.

The EPROM is chip-enabled when address A15 goes high and fed to the active low input via NAND gate IC7d wired as an inverter and is capable of being read when the E pulse and the read/write lines of the microprocessor are both high and fed to the active low read enable line of the EPROM via NAND gate IC7c. The EPROM is address decoded to a hex base address of 8000h to 87FFh. Since the address lines A11 to A14 inclusive are not decoded ghosts of the EPROM will appear at higher addresses, allowing access to the interrupt vectors. The internal RAM is address decoded to hex address range 0080h to 00FFh. See memory map of Figure 4.

The 4MHz crystal is divided by 4 internally by the microprocessor to provide an E pulse of 1MHz and a clock cycle time of 1 micro-second. The timing pulse E is further

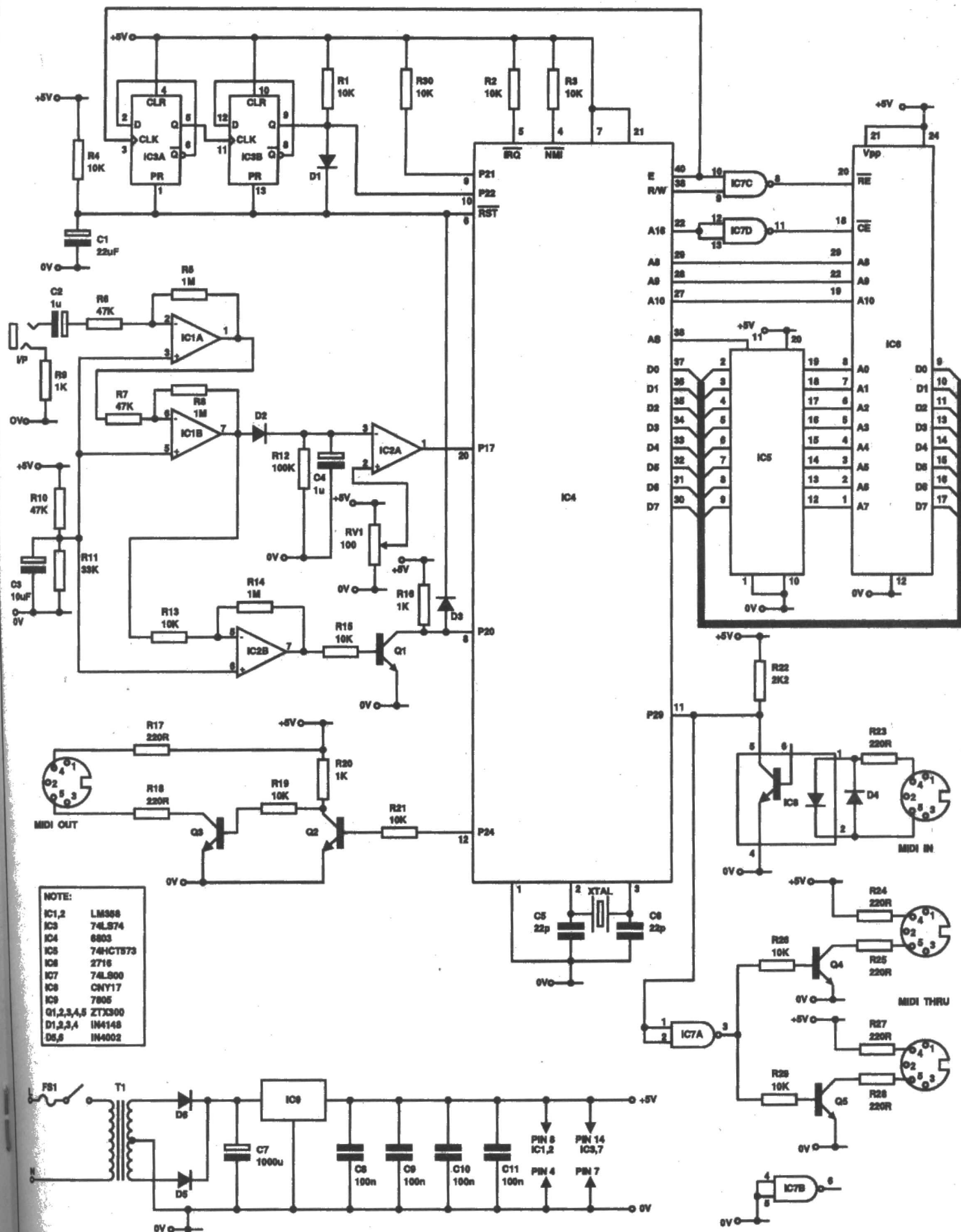


Fig.1 Circuit diagram of the sound to MIDI processor

divided by 4 by the dual D-Type flip-flops IC3a,b and fed to the serial external clock input on port 2 pin 2 (P22), where it is further divided to provide the correct MIDI baud rate. A 2MHz crystal could be used to generate the baud rate internally but then the clock cycle time would be increased to 2 micro-seconds, which would reduce the frequency resolution of the internal timer by half.

The MIDI IN connector is fed to IC8 optocoupler type CNY17 whose output is fed to the serial input P23 of IC4 and via inverting NAND gate IC7A and transistors Q4, Q5 to the MIDI thru' outputs. This allows splitting of the MIDI signal to two destinations. Also the serial MIDI input data to IC4 can be used for future MIDI applications.

The remaining NAND gate IC7b can have its inputs connected to ground or left floating.

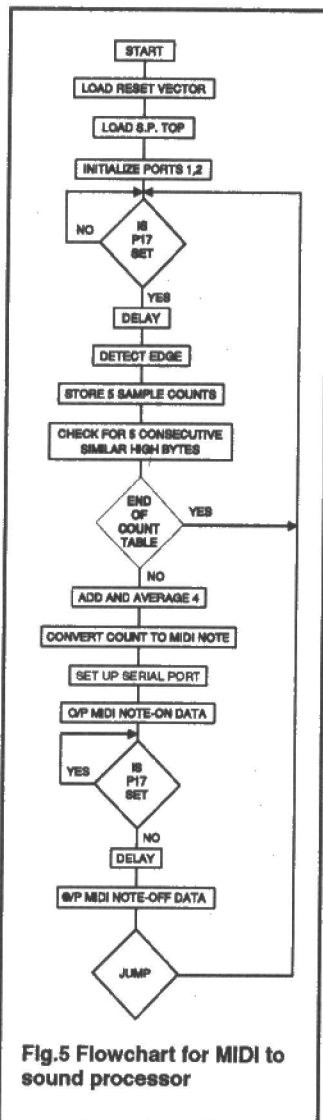


Fig.5 Flowchart for MIDI to sound processor

AC voltage swing using the LM358 IC. The capacitor C3 ensures that these inputs are AC grounded.

If the input is removed R9, which connects the preamplifier input to ground via the input jack, helps prevent spurious noise causing the circuit to operate intermittantly.

The amplified signal is then split and coupled to:

1) A Schmitt trigger circuit consisting of IC2b and associated components R13, R14 which set the threshold voltages. This signal is then fed to the serial port P20 via transistor Q1 which allows the signal swing from 0V to 5V.

2) A comparator circuit IC2a via rectifier diode D2 and

## Analogue Circuit

A microphone or other low level source (e.g. a guitar pickup) can be connected to the input preamplifier IC1a.

The mid-band gain, of approximately 20, is set by -R5/R6, the lower cut-off frequency is dependent on the combination of C2R6.

The second stage of amplification is provided by IC1b with a gain similar to the first stage set by -R8/R7. This gives an overall gain of over 400 or 52dB.

The potential divider R10,R11 sets the DC bias on the outputs of the operational amplifiers IC1a and IC1b via the non-inverting inputs, and IC2b via the inverting input, to half the supply potential minus approximately 1.5 Volts, which is the value required for the maximum symmetrical

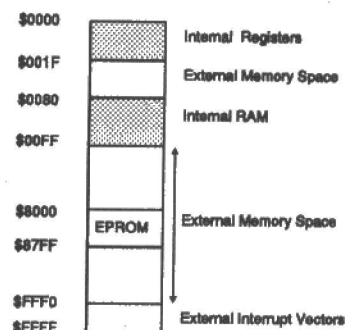
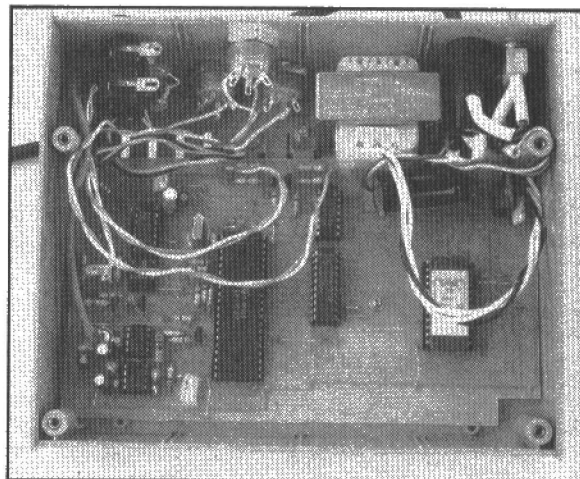


Fig.4 Memory map: Mode 2

smoothing circuit C4,R12. The level at which the output of IC2a switches is controlled by the setting of RV1, this output is fed to port 1 position 7 (P17) where it is polled by the software to detect the start and end of a musical note.

## Power Supply

The conventional power supply consists of a 9V - 0 - 9V transformer T1 with a VA rating capable of providing the required DC current of nearly 250mA. A capacitor C7



provides smoothing of the full-wave rectified output from diodes D4, D5 which feed a standard 7805 regulator IC9, to provide a regulated 5V output. Distributed capacitors C8 to C11 provide high frequency and noise rejection on the power supply lines of the PCB.

## Software

The operation of the software can be seen from the flowchart of Figure 5. First the reset vector is loaded from addresses 80FE, 80FF which are ghost addresses for the actual addresses at FFFE, FFFF. Next the serial, parallel and timer ports are initialised.

The software now polls port 1 pin 7 (P17) until the output of comparator IC2a goes high and then proceeds after a short software delay.

The software is designed to ignore the initial transient of a musical note, when the incoming frequency still has not settled to its final value, by storing counts and checking for 5 consecutive similar high bytes, which indicates the conversion of approximately the same input frequency 5 times.

If 5 consecutive similar bytes are not found within the

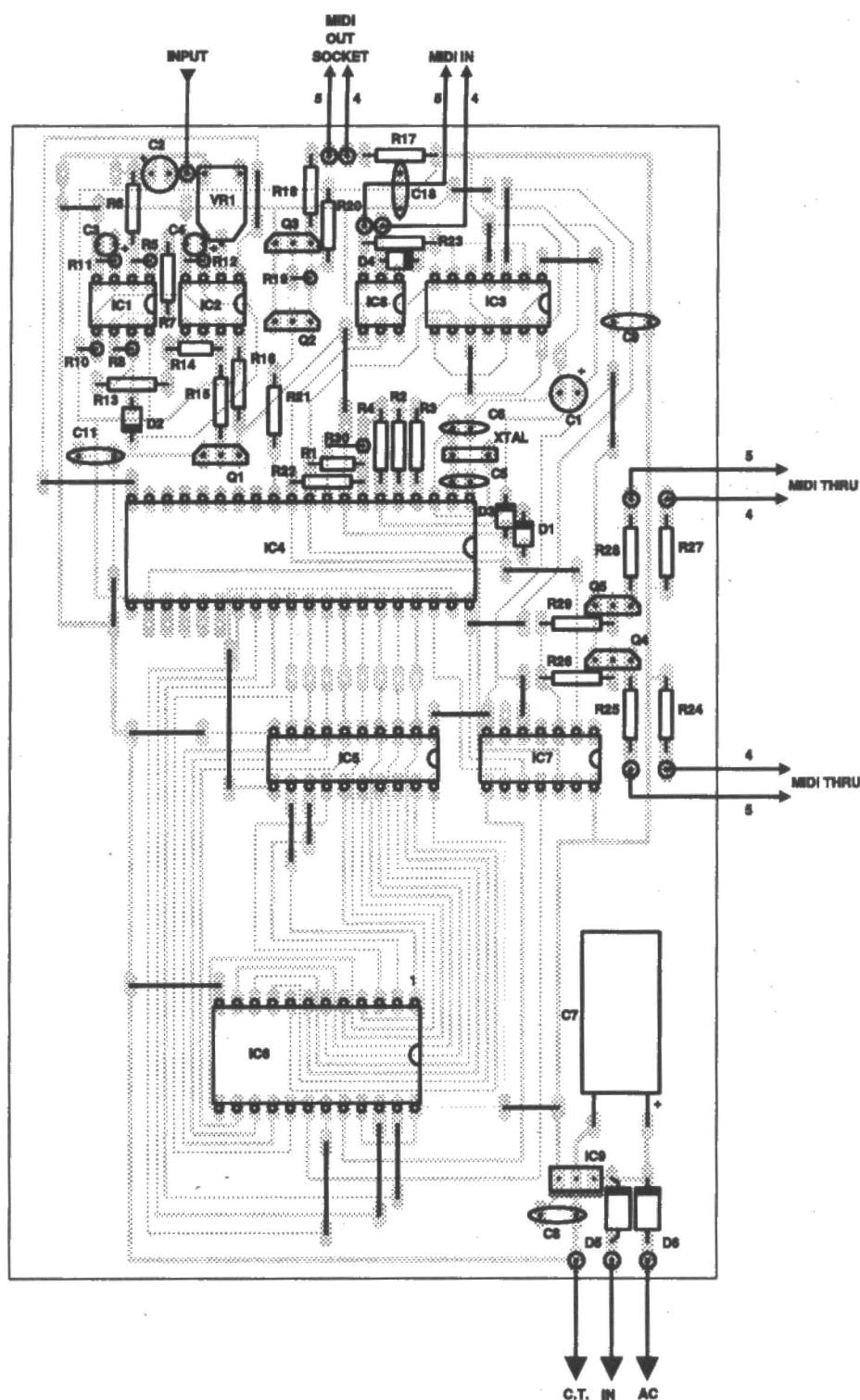


Fig.6 Component overlay

count table then the programme branches back to read pin P17. Otherwise 4 of these counts are added and averaged to produce a count number equivalent to the frequency of the input musical note. This number is then compared to a look-up table of numbers contained in the EPROM and converted to the equivalent MIDI note data. This number corresponds to the input frequency and is in the range from 0 to 127.

The number is then transferred to the parallel-to-serial port at P24 and is fed to the MIDI output via buffer transistors Q2 and Q3 at 31.25Kb with the MIDI protocol for a note-on event (see Figure 4). The software defaults to MIDI channel

1 and a velocity byte of 40h.

Now the software again polls P17 waiting for the musical note to end and then when IC2A goes low, after a short delay, the MIDI note-off data is transmitted to the MIDI out connector. Then the programme jumps back and waits until another note occurs.

## Operation

The circuit was designed for voice or any monophonic instrument and because the circuit converts the fundamental frequency so any instruments that contain a lot of harmonics

will not work correctly.

However I have used acoustic and electric guitars with the system and the problems associated with getting a good fundamental tone are:

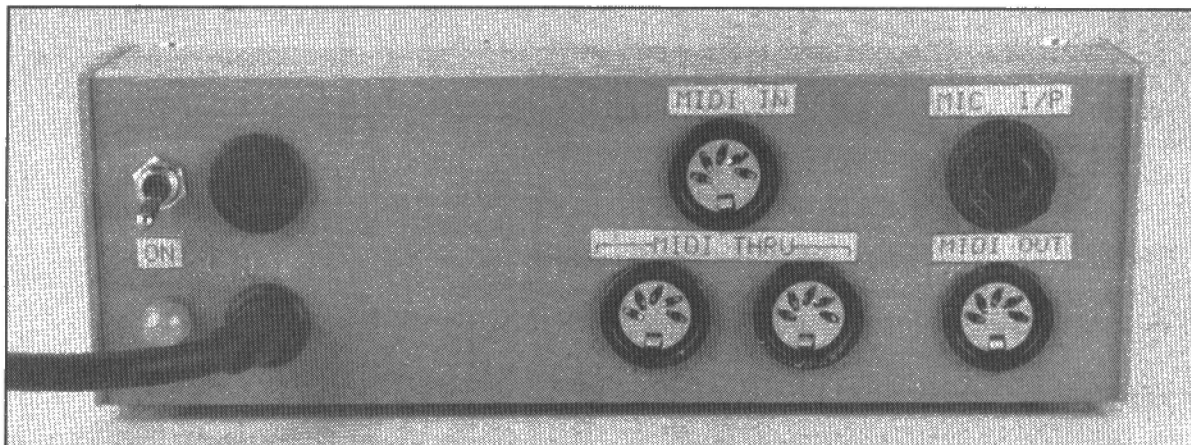
- 1) Initial transient overshoot.
- 2) Increase in harmonic content as note decays.
- 3) Harmonic content depends on how string is plucked.

The first problem is overcome by the programme software. The second can be cured by correct adjustment of preset RV1 for comparator IC2a. The third problem requires damping of the strings by hand or by placing absorbent material against the strings near the bridge of the guitar. Also I found that the best fundamental tone was produced on an

acoustic guitar by playing the middle of a string with my thumb rather than using a plectrum, which produced too many high frequencies.

The frequencies for a guitar range from a low E at 82.4Hz to approximately 1KHz for the topmost note depending on the make of guitar. However if a Bass guitar is used then the frequency goes down to 41.2Hz. However the lower the frequency the longer the conversion time and so the delay becomes discernable with very low frequencies.

I have used a tin-whistle with very good results and other instruments can obviously be used but some experimentation may be required to get a good fundamental tone.



**.MAIN PROGRAM.**  
**Hitachi 6301 Structured Cross Assembler**  
**Version 3.50 August 1987**  
**Program copyright MicroSol Ltd Dublin**

```

1          *****
2          *          SOUND TO MIDI          *
3          *****
4
5          0080      table      equ      $0080      5 incoming notes
6
7
8          *****
9          *          Table of MIDI notes C1 to C2          *
10         *****
11
12
13          .asct
14          0300      org      $0300
15
16          831A      ENDROMTABLE equ      $831A
17
18A 0300 3D37      ROMTABLE      fdb      $3D37
19A 0302 411C      fdb      $411C
20A 0304 44F8      fdb      $44F8
21A 0306 4912      fdb      $4912
22A 0308 4D69      fdb      $4D69
23A 030A 5203      fdb      $5203
24A 030C 56E4      fdb      $56E4
25A 030E 5C10      fdb      $5C10
26A 0310 6189      fdb      $6189
27A 0312 6757      fdb      $6757
28A 0314 6D7B      fdb      $6D7B
29A 0316 73FE      fdb      $73FE
30A 0318 7AE8      fdb      $7AE8
31
32          *****
33
34
35
36
37          07FE      asct
38A 07FE 8100      org      $07FE
39          fdb      $8100
40
41          0100      asct
42          org      $0100
43A 0100 8E 00FF      START      lds      #$00ff      load SP with top of stack
44
45          *****
46          *          InitiaIise ports          *
47          *****
48
49A 0103 86 7F      ldaa      #$7f      set port 1 with MSB as i/
50A 0105 97 00      staa      $0000
51
52A 0107 4F      clra          clear port 1 o/ps
53A 0108 97 02      staa      $0002
54
55A 010A 96 02      readp17     ldaa      $0002      read p17 and leave loop w
56A 010C 4D      tsta          comparator o/p is HIGH
57A 010D 27 FB      beq      readp17     if comparator o/p is low
58
59A 010F 4F      clrport     clra          clear port 2
60A 0110 97 01      staa      $0001      clear timer status reg
61A 0112 97 08      staa      $0008      detect note edge
62A 0114 BD 8260      jsr      $8260
63
64          *****
65          *          Delay for contact bounce          *
66          *****
67
68A 0117 CE 08BB      delay      ldx      #$08BB      delay value
69A 011A 09      dex
70A 011B 26 FD      bne      delay
71
72          *****
73          *          Store 5 sample counts          *
74          *****
75
76

```

```

77A 011D E 0080    sample    ldx    #0080    RAM look-up table
78A 0120 4F        store
79A 0121 97 01        staa    $0001
80A 0123 97 08        staa    $0008
81A 0125 BD 8260      jsr      $8260
82A 0128 97 09        staa    $0009    set timer to FFF8
83A 012A BD 8260      jsr      $8260
84A 012D DD C0        std      $00C0    var in 00C0
85A 012F BD 8260      jsr      $8260
86A 0132 93 C0        subd    $00C0
87A 0134 ED 00        std      0,x
88A 0136 08          inx
89A 0137 08          inx
90A 0138 BC 008A      cpx      #008A    END OF TABLE
91A 013B 26 E3        bne     store
92
93
94      *      Check for five consecutive numbers      *
95      *      *      *      *      *      *      *
96
97A 013D 7F 00E2      clr      $00E2
98A 0140 E 007E      ldx      #007E    START OF TABLE -2
99A 0143 8C 008A      cpx      #008A    END OF TABLE
100A 0146 24 C2      bhs     readpl7
101A 0148 08          inx
102A 0149 08          inx
103A 014A EC 00      ldd      0,x
104A 014C A1 02      cmpa    2,x
105A 014E 26 F3      bne     count
106A 0150 86 03      ldaa    #3
107A 0152 97 E0      staa    $00E0
108A 0154 08          inx
109A 0155 08          inx
110A 0156 EC 00      ldd      0,x
111A 0158 A1 02      cmpa    2,x
112A 015A 26 E7      bne     count
113A 015C 7A 00E0      dec     $00E0
114A 015F 26 F3      bne     loop3
115
116      *      *      *      *      *      *      *
117      *      Add four consecutive counts      *
118      *      *      *      *      *      *      *
119
120A 0161 86 03          ldaa    #3
121A 0163 97 E1          staa    $00E1
122A 0165 EC 00          ldd      0,x
123A 0167 09          add     dex
124A 0168 09          dex
125A 0169 E3 00          addd    0,x
126A 016B 24 03          bcc     four
127A 016D 7C 00E2      inc     $00E2
128A 0170 7A 00E1      dec     $00E1
129A 0173 26 F2          bne     add
130
131
132      *      *      *      *      *      *      *
133      *      Average of four numbers      *
134      *      *      *      *      *      *      *
135
136A 0175 7D 00E2      tst      $00E2
137A 0178 27 05          beq     clear
138A 017A 04          lsr     divide by 2
139A 017B 88 80          adda    #580
140A 017D 20 01          bra     nocarry
141A 017F 04          clear    lsr
142A 0180 04          nocarry    lsr     divide by 2
143
144
145      *      *      *      *      *      *      *
146      *      Convert count to MIDI note      *
147      *      *      *      *      *      *      *
148
149A 0181 DD 91          std      $0091
150A 0183 CE 8300      ldx      #8300
151A 0186 86 01          ldaa    #1
152A 0188 97 90          staa    $0090
153A 018A DC 91          ldd      $0091
154A 018C A3 00          subd    0,x
155A 018E 24 0A          bhs     octave
156A 0190 7C 0090      inc     $0090

157A 0193 DC 91          ldd      $0091
158A 0195 05          asld
159A 0196 DD 91          std      $0091
160A 0198 20 F2          bra     checkoct
161
162      *      *      *      *      *      *      *
163      *      Find MIDI note in a given octave      *
164      *      *      *      *      *      *      *
165
166A 019A 86 17          octave    ldaa    #17
167A 019C 97 93          staa    $0093
168A 019E 08          note    inx
169A 019F 08          inx
170A 01A0 8C 831A      cpx      #ENDROMTABLE
171A 01A3 27 4E          beq     repeat
172A 01A5 DC 91          ldd      $0091
173A 01A7 A3 00          subd    0,x
174A 01A9 23 05          bls     calc
175A 01AB 7A 0093      dec     $0093
176A 01AE 20 EE          bra     note
177
178      *      *      *      *      *      *      *
179      *      Calculate MIDI note value      *
180      *      *      *      *      *      *      *
181
182A 01B0 01          calc     nop
183A 01B1 01          nop
184A 01B2 01          nop
185A 01B3 C6 0C          ldab    #50C
186A 01B5 96 93          ldaa    $0093
187A 01B7 7A 0090      calclp    dec     $0090
188A 01BA 27 03          beq     tab
189A 01BC 1B          aba
190A 01BD 20 F8          bra     calclp
191A 01BF 16          tab
192
193      *      *      *      *      *      *      *
194      *      Set up serial port for MIDI      *
195      *      *      *      *      *      *      *
196
197A 01C0 86 0C          ldaa    #50C
198A 01C2 97 10          staa    $0010
199A 01C4 86 02          ldaa    #2
200A 01C6 97 11          staa    $0011
201
202      *      *      *      *      *      *      *
203
206A 01C8 8D 2C          bsr     empty
207A 01CA 86 90          ldaa    #590    note on channel 00
208A 01CC 97 13          staa    $0013
209A 01CE 8D 26          bsr     empty
210A 01D0 D7 13          stab    $0013    store note to serial port
211A 01D2 8D 22          bsr     empty
212A 01D4 86 40          ldaa    #540    velocity mid value
213A 01D6 97 13          staa    $0013
214
215      *      *      *      *      *      *      *
216      *      Test for end of note      *
217      *      *      *      *      *      *      *
218
219A 01D8 96 02          noteoff    ldaa    $0002    contents of port 1
220A 01DA 4D          tsta
221A 01DB 26 FB          bne     noteoff
222
223      *      *      *      *      *      *      *
224      *      Delay for contact bounce      *
225      *      *      *      *      *      *      *
226
227A 01DD CE 08B8      bounce    ldx      #08B8    delay
228A 01E0 09          dex
229A 01E1 26 FD          bne     bounce
230
231      *      *      *      *      *      *      *
232      *      Transmit MIDI note off data      *
233      *      *      *      *      *      *      *
234
235A 01E3 8D 11          bsr     empty
236A 01E5 86 80          ldaa    #580    note off channel 00
237A 01E7 97 13          staa    $0013
238A 01E9 8D 0B          bsr     empty

```

```

239A 01EB 07 13      stab $0013   store note to serial port
240A 01ED 80 07      bsr empty
241A 01EF 86 40      ldaa #540   mid velocity value
242A 01F1 97 13      staa $0013
243A 01F3 7E 810A    repeat jmp $810A   back to readp17
244
245 *****
246 *      TDR empty subroutine      *
247 *****
248
249A 01F6 96 11      empty ldaa $0011
250A 01F8 85 20      bita #520
251A 01FA 27 FA      beq empty
252A 01FC 39          rts
253
254 *****
255 *      EDGE detect subroutine    *
256 *****
257          asct
258          org $0260
259A 0260 96 08      EDGE ldaa $0008   timer status reg

```

```

260A 0262 2A FC      bpl EDGE
261A 0264 DC 0D      ldd $0000   input capture reg
262A 0266 39          rts
263
264
265
266
267
268
269
270          end

```

Symbol Table:

EDGE	0260	ENDROMTA	831A	ROMTABLE	0300	START	0100	__LNG	0000
__LST	0001	__SAVE	0001	__SAVB	0001	add	0167	bounce	01E0
calc	01B0	calclloop	01B7	checkoct	01B0	clear	017F	clrport	010F
count	0143	delay	011A	empty	01F6	four	0170	loop3	0154
nocarry	0180	note	019E	noteoff	01D8	octave	019A	readp17	010A
repeat	01F3	sample	011D	store	0120	tab	01BF	table	0080

RUN COMPLETE 0 ERRORS DETECTED

## PARTS LIST

### RESISTORS

R1,2,3,4,13,15,  
19,21,26,29,30 10k (11 off)  
R5,8,14 1M  
R6,7,10 47k  
R9,16,20 1k  
R11 33k  
R12 100k  
R17,18,23,24,25,  
R27,28 220  
R22 2k2  
RV1 100k

### CAPACITORS

C1 22µ  
C2 1µ  
C3 10µ  
C4 1µ/63V  
C5,6 22pF  
C7 1000µ  
C8,9,10,11 100n

### SEMICONDUCTORS

IC1,2 LM358  
IC3 74LS74  
IC4 6803  
IC5 74HCT573  
IC6 2716  
IC7 74LS00  
IC8 CNY17  
IC9 7805  
Q1,2,3,4,5 ZTX300  
D1,2,3,4 1N4148  
D5,6 1N4002

### MISCELLANEOUS

IC HOLDERS 6,20,24,40 1 OFF  
8,14 2 OFF  
T1 Transformer 9V-0V-9V,  
XTAL1 4MHz crystal,  
fuse 1A, LED, switch, din connectors 180°  
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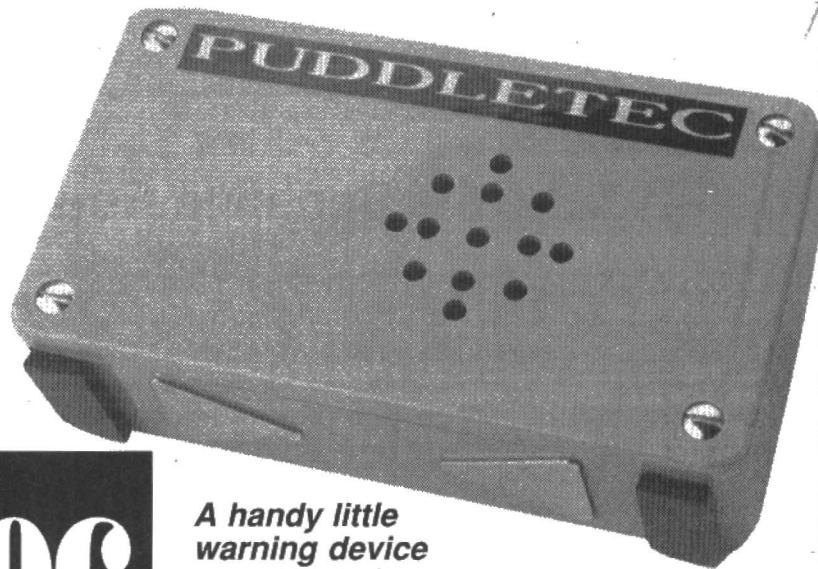
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GOULD OS3000B 50MHZ 2 TRACE DEL T/B	£269	FARNELL E350 0-350v 100mA, 2 x 6.3V	£49 to £99
TEK 453 50MHZ DUAL TRACE DEL T/B	£249	DEFIBRILATOR 50-400 JOULES BATT/MAINS	£49
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TEK 5L4N 100KHZ SPECT ANAL WITH 5110 M/F,		WAYNE KERR B321 LOW IND. BRIDGE	£39
2x 5A18N, 5B10N TIME BASE.	£750	HP1901A -05A -08A -17A 25MHZ PULSE GEN	£125
TELEQUIPMENT D75, 50MHZ 2 TRACE DEL T/B	£225	SCR 578N GIBSON GIRL EMERGENCY XMITTER	£75
TEKTRONIX 7403N, DF1, 7D01 LOGIC ANAL	£495	LEVELL TM88 MICRO V-METER 450MHZ	£95
TEK 545B, 585, 585A, 535A, 541A, 515A	From £49	TUBB/TUBB MICRO V-METER 3MHZ	£85
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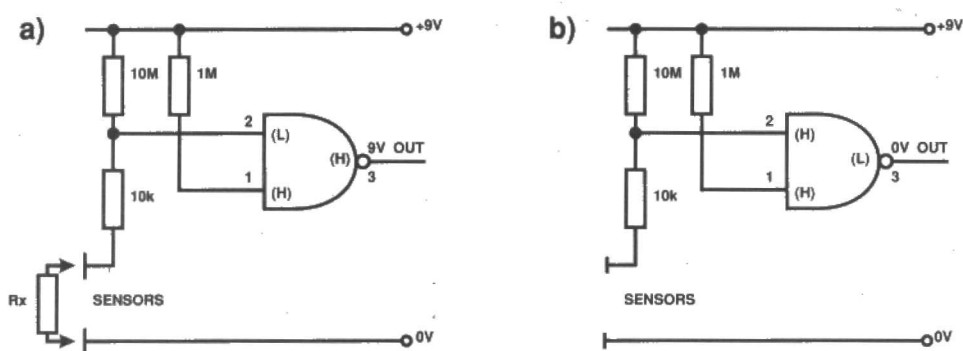
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# PuddleTec

*A handy little warning device constructed by Bob Noyes.*



**Fig.1 Detecting Action with a NAND gate**

Note: C1, D1 and D2 have been removed for simplicity as they do not affect the action of the logic.

	PIN 1	PIN2	PIN3
X	0	0	1
X	0	1	1
WATER	1	0	1
NO WATER	1	1	0

FIRST TWO NOT VALID

**Fig.2 Truth table of NAND gate**

**Y**ou know how it is - it's late, you load the dishwasher or washing machine and head off to bed thinking that everything's hunky dory. However, instead of waking up to clean dishes and clothes, you find yourself in need of flippers and a snorkel - one of these appliances of science has overfilled and flooded the kitchen floor causing serious damage to anything floor standing. It happened in our house once and I vowed that if it ever happened again I wanted to know about it from the onset, not hours later. Thus the idea for Puddletec was conceived. A simple device to detect water where water shouldn't be.

Because of the constant threat of water cascading from a washing machine or dishwasher the unit had to be battery driven so as to be completely safe, also it had to be kept on 24 hours a day. If it was a gadget that had to be got out and switched on each time an appliance was used, the novelty would soon wear off and you'd be back to square one. Puddletec had to be small and unobtrusive - stepping over it would be impracticable in the average kitchen. Another important consideration was the output - it had to be instantly identifiable as the Puddletec and not the buzzer from the oven timer or the microwave.

Hopefully, Puddletec fulfils these conditions - ours has worked well for nearly 5 years now. The battery, a PP3 long-life cell, is changed annually at the same time as the one in the smoke alarm. The principle that Puddletec works on is that water has a relatively low resistance and this characteristic can be used to operate an electronic switch built around a gate of a CMOS integrated circuit. The great advantage of CMOS as a range of ICs is that they draw almost no current

in operation so long as they are not used to sink or source power to external devices.

## The Output Stage

This consists of two sets of out of phase emitter followers with the output sounder connected between them. The emitter followers are basically a PNP and an NPN transistor with their bases connected together and their emitters connected together. In this mode and with their collectors connected to the supply they form a current amplifier. Q1 and Q3 are connected to the output of the AND gate and follow the output of this gate. The last gate of the IC is used as an inverter and simply outputs a low on pin 11 for a high on pins 12 and 13 and outputs a high for a low on pins 12 and 13. The output pin 11 is connected to another pair of emitter followers. This means that the emitters of Q1 and Q3 are always out of phase with the emitters of Q2 and Q4. This ensures the voltage swing across the sounder, a piezo sounder, is effectively doubled - increasing the volume from Puddletec when sounding. No other type of sounder i.e. buzzer etc can be used as the potential across it changes when sounding. When there is no sound i.e. dry conditions, it must have almost infinite resistance or there will be a constant load across the battery reducing its life to only a few hours and hence be totally impracticable.

## The Box

A small plastic box approx 65mm x 115mm x 30mm was chosen because, when in position, it occupies only a footprint of 30mm x 115mm which can tuck under the lip at the base

## HOW IT WORKS

The electronic switch is built around one of the four NAND gates in a 4093 (Quadruple 2-input NAND Schmitt trigger) IC. The Schmitt action of the IC has several uses, for example voltages between normal (High) and normal (Low) can be applied to the input of IC without causing damage and the IC will still switch its output to a true high or low. IC1 pin 1 is tied to the rail by R3 a 1M resistor. The other input, pin 2, is tied to the rail by R1 a 10M as well as being taken through a 10k R2 to one of the sensor terminals. Diodes D1 and D2 prevent any external static voltages from damaging the IC and C1 damps out any RF signals picked up. In normal conditions, the switch has two high signals applied to the input causing its output pin 3 to be low. If however water is detected by touching the two sensors, one going to pin 2 via R2 the other to 0V of the battery, the effective resistance between pin 2 and 0V will reduce to well below 1M. This is more than enough to be seen as a low (below 40% rail) and hence the output pin 3 will go high through the NAND action of the gate. (See Truth Table of NAND Gate)

In order to be instantly identifiable, the output is a series of beeps. Each beep is longer than the gap between beeps - this has two advantages: (1) it is more distinctive than a constant beep and (2) it saves power.

The series of bleeps are generated by two oscillators, one high frequency and variable for maximum volume (which is the resonant frequency of the sounder). The other oscillator acts as a switch gating the first oscillator on and off through the discrete AND gate D4, D5 and R7.

**Oscillator 1** (the high frequency variable one).

This is built around gate c pins 8-9 in and pin 10 out. The timing elements of this oscillator are C2 and the combination of R4 and RV1. When pin 8 is made high by the detection of water the oscillator is enabled and will oscillate at a frequency depending upon the setting of RV1. It will oscillate all the time pin 8 is high and water is detected.

**Oscillator 2** (the pulsing one).

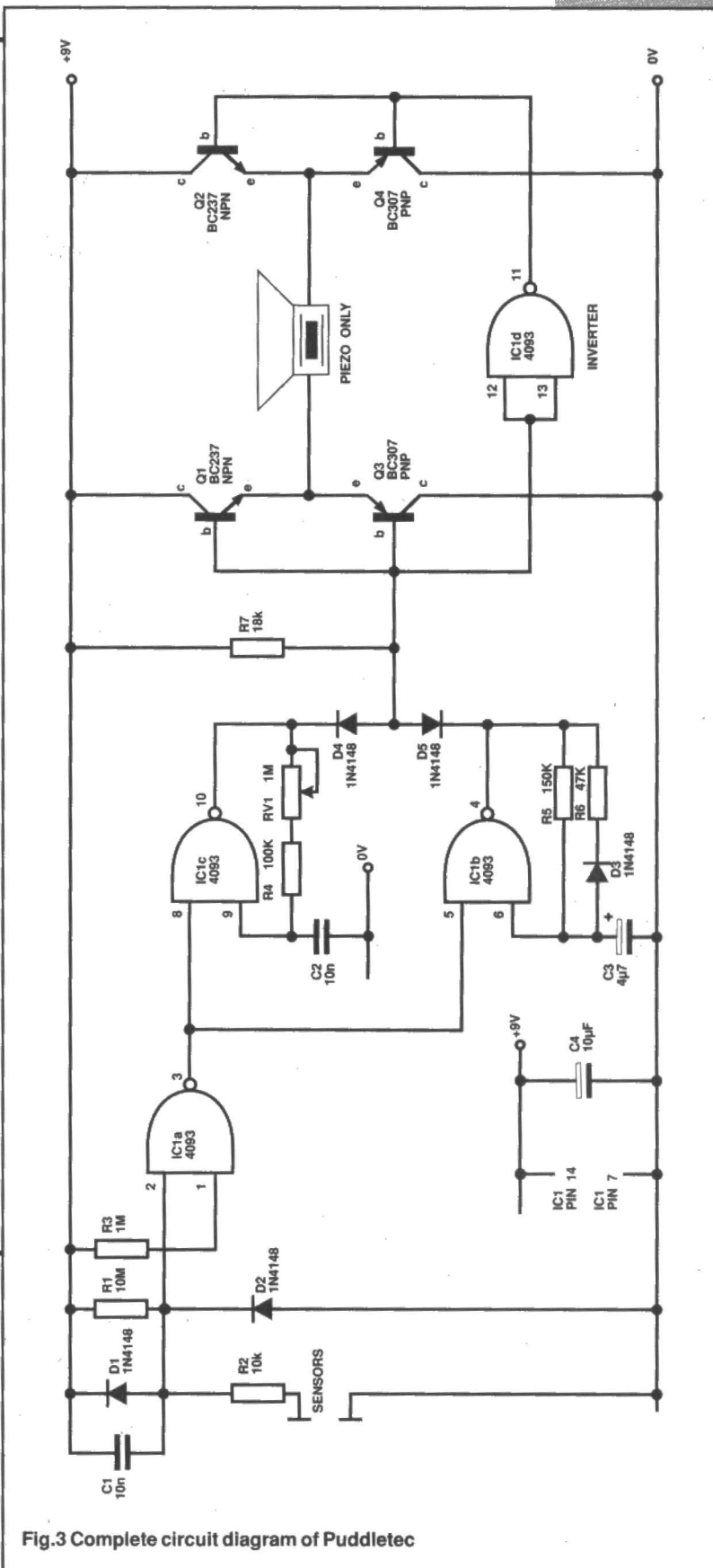
This is built around gate b pins 5-6 in and pin 4 out. This is basically the same type of circuit as oscillator 1 but runs a lot slower as C3 is much larger than C2. The resistive element of the oscillator is slightly different as only R5 is used to charge C3 but R6 is used in parallel with R5 to discharge C3 via the action of D3, meaning the on and off time of the output of the oscillator is not the same. It is this uneven mark to space relationship which sounds the bleep for longer than the gap between bleeps.

The two oscillators are gated together by a discrete AND gate made up from D4, D5 and R7. When pin 4 of the slow oscillator is low the output of the discrete AND gate is low and prevents the output of the fast oscillator, pin 10, from getting to the output stage. When pin 4 goes high then the fast oscillator is allowed through to the output stage.

of the washing machine/dishwasher - hardly protruding at all.

Once the components have been soldered it would be wise to melt solder onto the trackwork assuming a home-made board. This increases the long term reliability as dampness, could easily corrode the board. The circuit should be checked again to ensure no shorts have been introduced i.e. blobs of solder linking parallel tracks. The track and solder connections should then be cleaned with a solvent cleaner to remove surface flux etc. No switch is included because in normal use the battery will last well over a year, although changing it annually is a wise move. Puddletec draws around 10µA not sounding and 2.5mA sounding.

The box can be drilled as shown in the diagram. The sensors are Maplin triangular ones - if you are not able to get hold of these then ordinary metal bolts will do (brass preferably, to prevent rusting). Care must be taken that the sensors do not touch the floor as this will increase the



**Fig.3 Complete circuit diagram of Puddletec**

likelihood of them scratching it. They should also be held just off the floor to stop any condensation that may be present from setting Puddletec off. The Maplin sensors, if fitted, will have to have their fixing bolts cut to prevent them shorting out with the circuit board when it is fitted.

Before fitting the circuit board it should be tested. Care

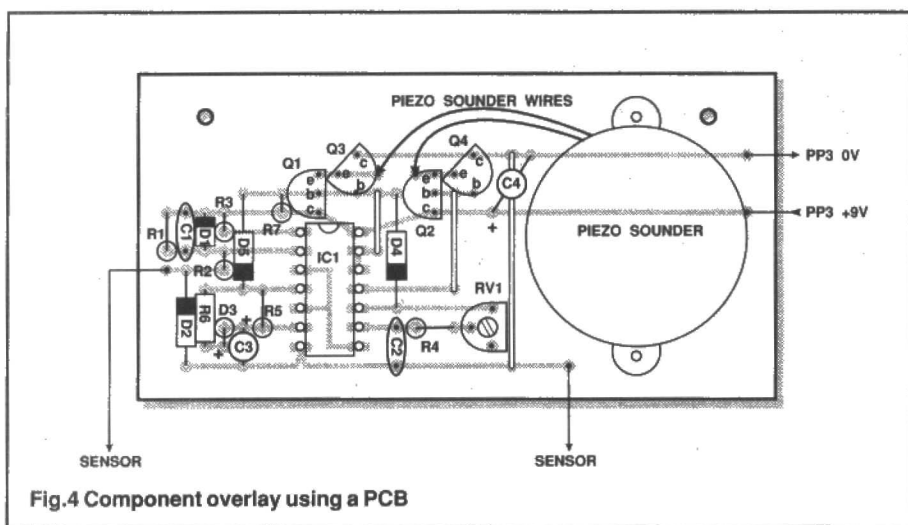


Fig.4 Component overlay using a PCB

should be taken when handling the board as even skin resistance on the input stage may set Puddletec off. The circuit should work once the battery is connected. To test it, simply touch both of the sensors; this should start the sounder which will pulse. Adjusting RV1 will change the frequency of the sounder (not the pulsing rate) and it should be set to the loudest sound - this will be at, or nearest to the resonant frequency of the piezo. Releasing the sensors should stop the sound.

Holes in the lid of the box are necessary to let the sound out and these can be drilled in a pattern of small holes rather than one big one. A spare piece of Veroboard can be used as a template and a symmetrical pattern can be made using the 0.1" grid of the Veroboard and drilled with a 1mm drill. This can be taped on the box lid and held down securely while the

flooded one will not upset the device as there should be a sufficient gap between the sensors and the floor.

Other uses have been found for Puddletec such as in DIY plumbing Jobs. When repairing an overflowing tank, placing Puddletec underneath will soon let you know how good a plumber you are.

### Possible Modifications

The input sensitivity can be reduced by reducing the 10M (R1) to any value down to 1M. This can be experimented with to suit the application. The pulsing rate can be decreased by increasing the value of C3 or increased by reducing the value of C3.

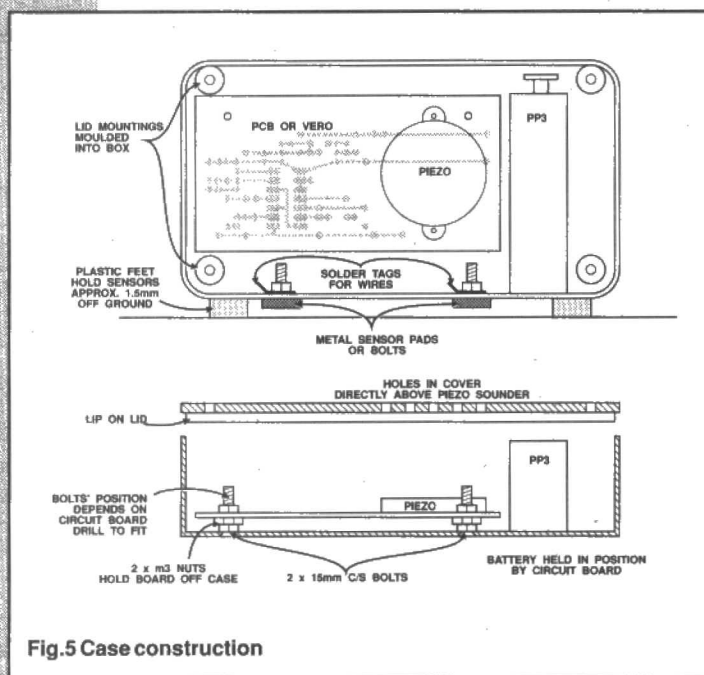


Fig.5 Case construction

holes are drilled through again, this time into the lid. Their position must be directly above the sounder, as shown in the diagram. The template can then be removed and the holes in the lid opened out to the desired size (3mm is recommended). When everything is working, the board is mounted off the bottom of the box by a couple of nuts on the bolts from the

back. These hold the board about 5mm away from the back of the box. The board also helps hold the battery in place. When complete, hold the battery in place and check nothing moves or is loose and that no bits and pieces are left in the bottom of the box by turning it upside down. When you're happy, the lid can be bolted down.

When the kitchen floor needs a wash, simply pick Puddletec up and put it back when it's done. A damp floor as against a

### PARTS LIST

#### RESISTORS

- 1/4w 5%  
 R1 10M  
 R2 10k  
 R3 1M  
 R4 100k  
 R5 150k  
 R6 47k  
 R7 18k  
 RV1 10M sub min vertical enclosed

#### CAPACITORS

- C1,2 10n  
 C3 4u7 tant  
 C4 10u tant

#### SEMICONDUCTORS

- IC1 4093  
 Q1,2 BC237 or BC171  
 Q3,4 BC307 or BC557  
 D1,2,3,4 1N4148

#### MISCELLANEOUS

**Plastic box** from Electromail/RS, part no. 508 914. Dimensions 112 x 62 x 31mm or larger (smallest practical box). Slightly larger 129 x 64 x 42mm - Maplin, part no. YU 53H.

**Battery:** Duracell or other long life alkaline type PP3. Battery connector: PP3, Maplin part no. HF28F. Piezo sounder/transducer (not buzzer): Maplin part no. FM59P.

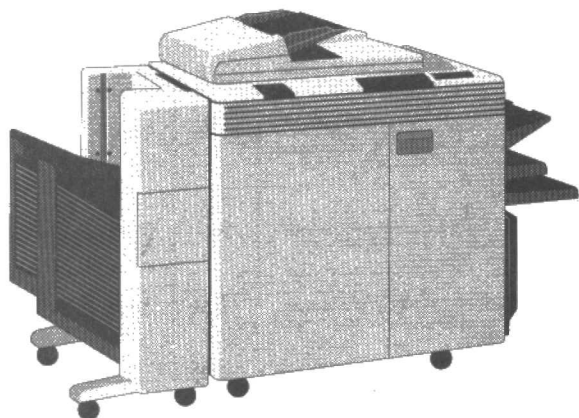
**IC holder** if required: Maplin part no. BL18U. DIL 10 way switch made out of 8+2 way: Maplin part nos. QY70M (8 way) and JH09K (2 way).

**Two touch pads:** Maplin part no. HY01B. Nuts, bolts size M3 to suit.

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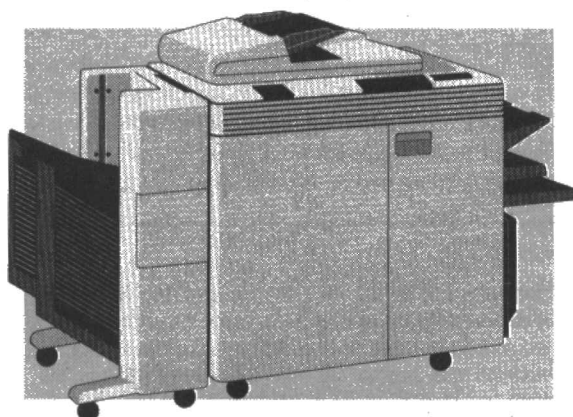
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# DiscoAmiga

*Marcus Pihl will show you how to impress your friends with a computer controlled lightshow.*

**L**ightshow systems for the home are not easy to find. Especially when everyone should be able to afford it. With this project you can control two rotating lights, one stroboscope and four spotlights. But it is easy to rebuild it for your own needs. If you synchronize your favourite music to the system and teach your computer "what to do", it can replay the recorded sequence, by using a listed program.

To begin with, there are two separate interfaces—one for the motors and one for light selecting. What both PCB's have in common is that they are totally isolated from external voltages that might damage your computer if something should go wrong. That is easily done with some optoswitches. Let's take a look at the interface for the steppermotors.

As the databus should not be connected directly to ground through the LED in the optoswitch, an extra transistor and resistor is coupled to this LED. Now, the maximum current through each databit is 0.43mA and so your output buffer in your computer is safe. This transistor is also used as an inverter. When the computer is turned on all databits go 'high' 1. If we had used the transistor without inverting, the outputs would be short-circuited, because all LED's in the optoswitches would light and the current would pass 'straight down', (see schematics) instead of passing through each coil in the motor.

When we look at the other side of the optoswitch there is a new voltage. No connection at all with the computerside, not even ground. That's the point of using optoswitches.

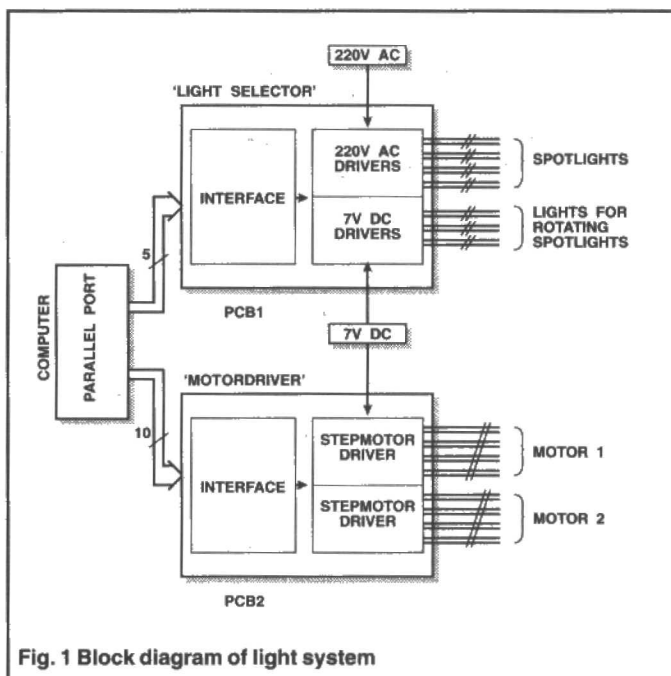


Fig. 1 Block diagram of light system

The problem with steppermotors is that the polarity must be changed all the time in a particular way. The only way to do this, is to use four transistors for each coil in the motor. This ends in eight power transistors for each motor, making 16, if we want two rotating lights.. They may need cooling, if the resistance in the motor is too low than recommended. Don't forget to mount the diodes. They protect the power transistors from being destroyed by the motors, so they are important.

## HOW IT WORKS.

To begin with the steppermotor interface, uses all eight bits in the databus - four for each motor. To understand how to run these motors we'll take a look at a simple diagram:

"1/2 phase excitation"								
time->	1	2	3	4	5	6	7	8
L1a	+	+	+		-	-	-	
L1b	-	-	-		+	+	+	
L2a	-		+	+	+		-	-
L2b	+		-	-	-		+	+

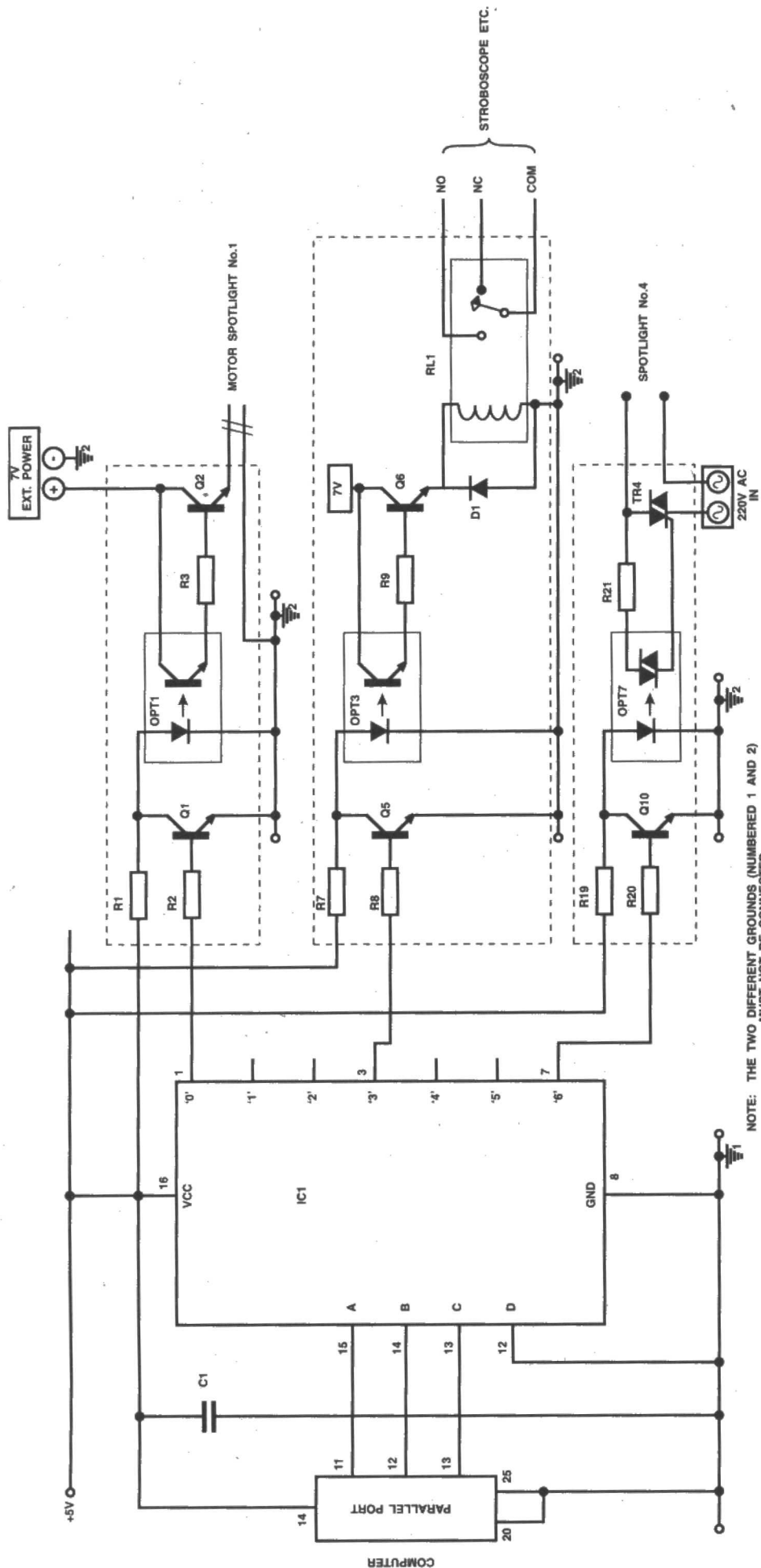
One step

(1 turn is normally about 200 steps)

These pulses will move the axis in the motor one step with halfphase excitation. But a normal steppermotor only moves around 1.8 degrees per step, so about 200 pulses (with eight polarization

changes) has to be made to rotate the motor 360 degrees. To reverse the motor just send the pulses backwards, beginning with 8 and ending with 1, and restart at 8 again to continue. To stop the motorised lights there are two ways. The first way is to 'park' the motor so it hangs down. To do this in the correct way, the motor should be moved straight down before cutting off the power from both coils. But if we stop and send new pulses, the motor will stay in position and it will hang until we continue to send new pulses. If we cut off the power, the lightunit will fall down to 'start position', a less than professional approach.

If the LED in OPT1 is active while OPT2's LED is inactive the potential difference between L1a and L1b is positive. If we change the action round in the opto-isolators the voltage is reversed. If both LED's should be high, the external voltage would be short circuited. If neither are alight, no power exists in L1, and the motor hangs free. If we now program our computer to send the sequence to the optoswitches, the motor will move as we want.



NOTE: THE TWO DIFFERENT GROUNDS (NUMBERED 1 AND 2) MUST NOT BE CONNECTED

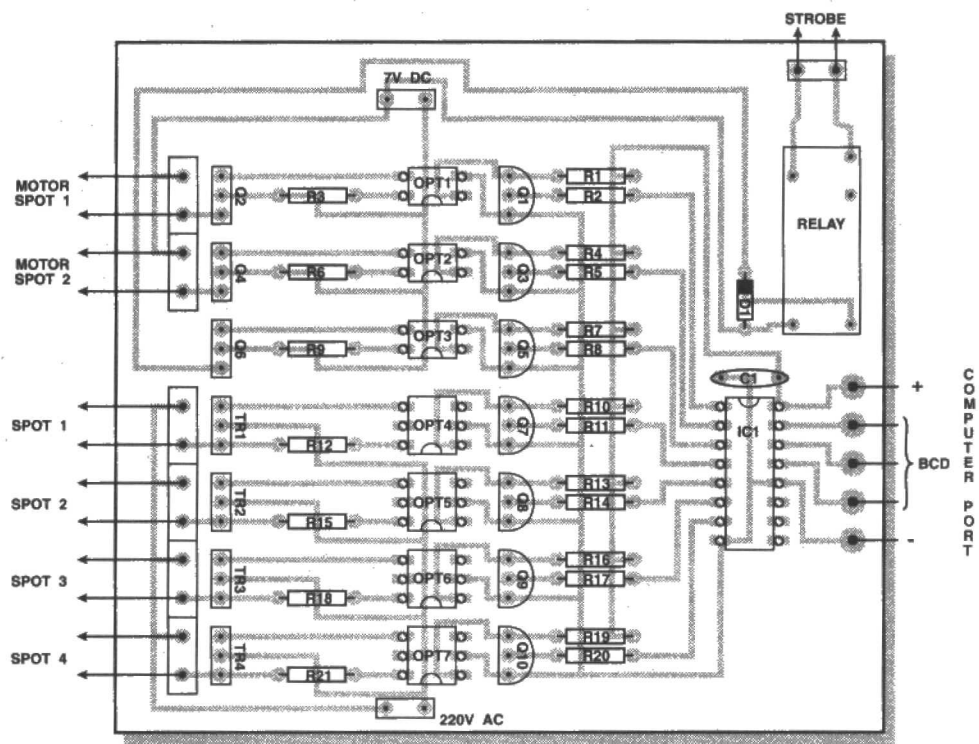
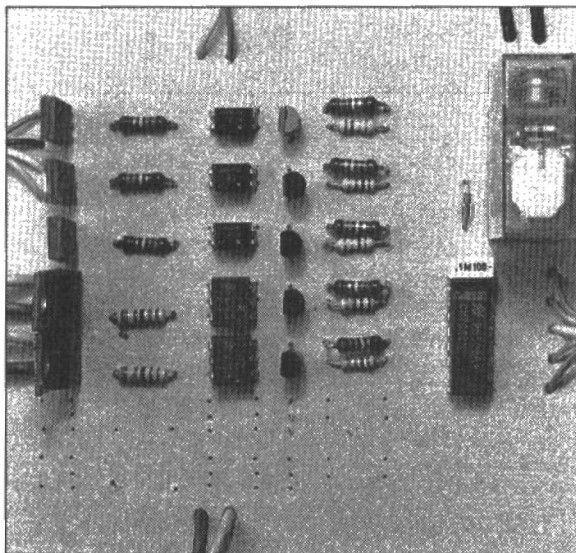


Fig. 3 Component overlay for Light Selector Card



### Light-selector interface

This part of the project uses the same connector as the stepmotor interface does. The three extra status signals from the connector (11,12,13) is connected to a BCD to decimal decoder. The input D is earthed to ground, because we're running out of control signals. It was felt that seven different lights should be enough. From each output of the 74LS42 a resistor is coupled to a driver transistor for extra current drive. The transistor is also used as an inverter, similarly to the stepmotor interface transistors.

From the output of the optoisolators you have a choice to connect whatever you want. Firstly there are the two light-bulb switches being turned on and off by a power transistor. Then there is a stroboscope output which uses a relay to activate the flash. The stroboscope you connect it to must have an output for external trigger. This should be a short-circuit to have the stroboscope flashed. Otherwise, use a

spotlight-switch to turn the power on and off.

The spotlight switch uses another method to control the light. The optoiswitch uses a triac to switch the bigger power triac which may switch up to 8A. In that case, the triac must be cooled. I use normal spotlights which is enough for my use.

**CONTINUED NEXT MONTH**

### PARTS LIST

#### RESISTORS

R1-R8	10k
R40-R46	10k
R9-R16	330
R33-R39	330
R17-R32	1k
R47-R49	2k
R50-R53	4k7

#### CAPACITORS

C1	100n/16V
----	----------

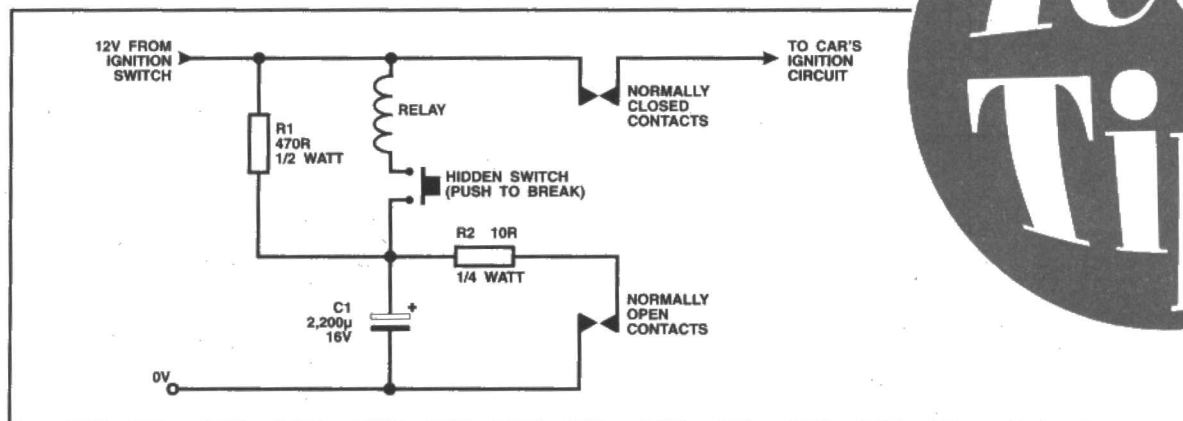
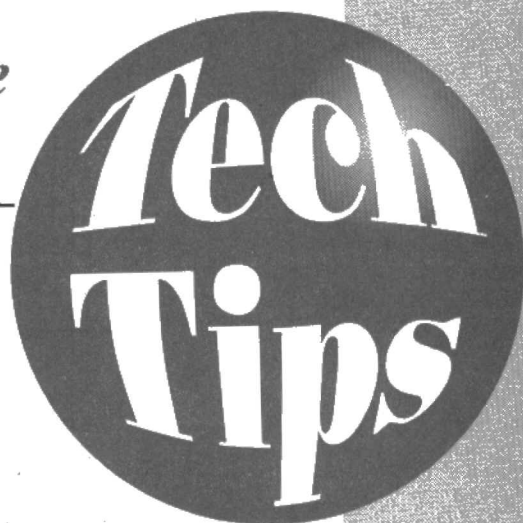
#### SEMICONDUCTORS

Q1-8	BC546B
Q25-31	BC546B
Q9-24	BC337-25
Q32-34	BD683
TR1-4	TIC225D
OPT 1-11	PC715
OPT12-15	MOC3021
D1-17	1N4003
IC1	74LS42

#### MISCELLANEOUS

RLY1	Relay. 6V 500V, 0.5A MZP A001 4205
K1	25-pin DSUB male
Case to K1	
Suitable connectors for outputs.	
13way cable.	
Plastic case to mount the card in. (With cooling)	

# Self-arming Anti-theft Device for Cars



**T**his circuit has been fitted in my car for a number of years. Originally designed as a self arming anti-theft device, the unit will also provide some protection against hi-jack, which has become a mode of operation for some thieves.

**In operation** (Without the hidden switch SW1 pushed).

When the ignition circuit is energised C1 charges via R1 and the relay, causing it to energise and latch via contacts 1 and R2. Other relay contacts break the supply to the cars ignition circuit.

When the ignition circuit is energised with switch SW1 pushed, C1 is charged via R1 within a short time, and the relay now cannot energise.

If the anti-theft device is accidentally set, unsetting is achieved by powering down the ignition, de-energising the

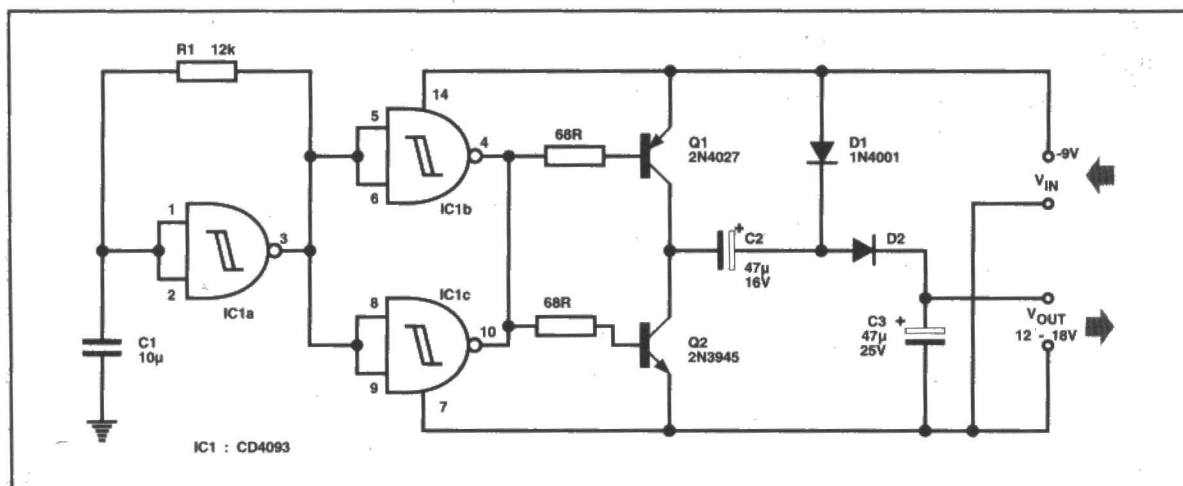
relay.

Many of the component values are not critical, however C1 must be large enough to cause the relay to energise. The value given works for a 12 Volt 110 Ohm coil. R1 should allow C1 to charge within a short time with SW1 pushed. R2 must limit the maximum capacitor discharge current within the specification of C1 and not have a large voltage across it when the relay is energised, which may cause it to dropout.

Some consideration should be given to the location of the hidden switch, since it has to be operated while the ignition key is turned.

Each time the cars ignition circuit is switched off, the circuit is automatically armed. Should some one get into your car and attempt to hi-jack you, simply switch off the ignition.

Mike Dyer, St Albans, Herts



## DC Voltage Doubler

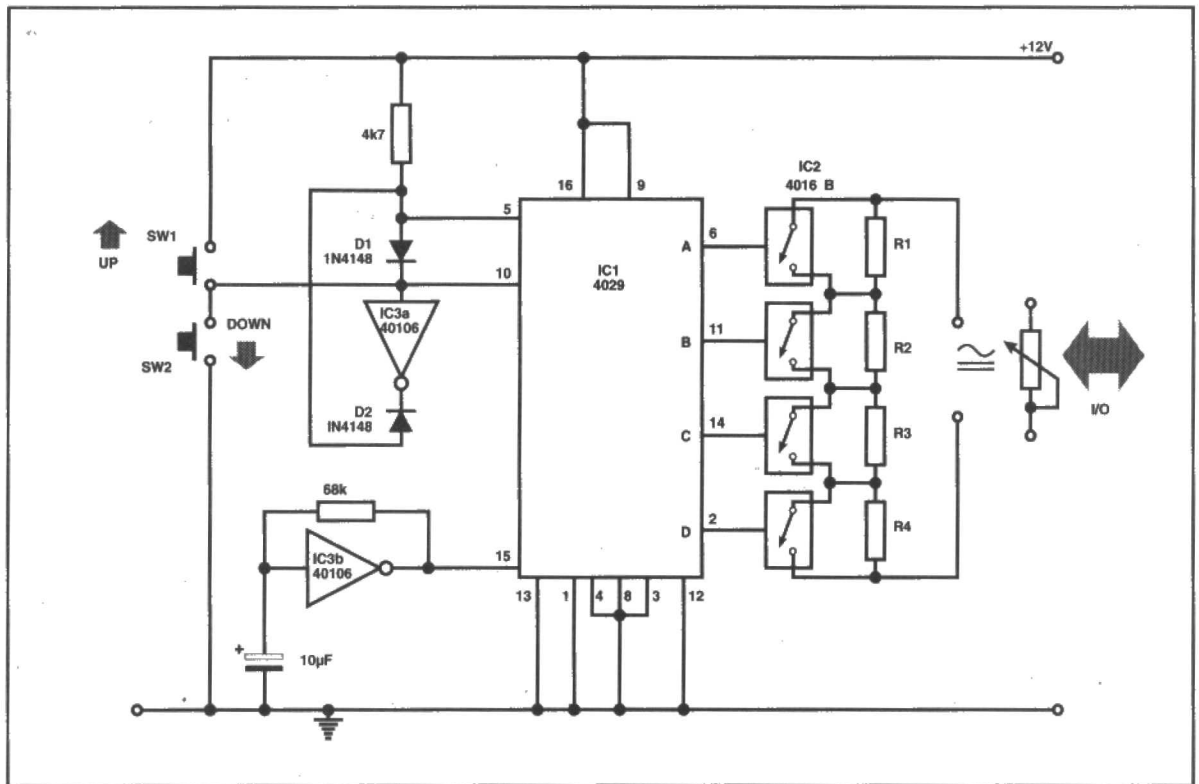
**A** handy yet simple voltage doubler can be realised around a single CMOS Quad Schmitt trigger type 4093. The circuit can provide up to 50mA at input voltages between 6-9V. This typically can be handy when, say one needs to power an op-amp from a 5V supply rail!

IC1a is wired as an astable oscillator running at 10kHz. This oscillator drives two buffer inverters built around IC1a and IC1c - two of the four available NAND gates of the

integrated circuit used. When Q2 is conducting, then C2 charges to approximately the input/positive rail voltage. Then during the next cycle, when the opposite transistor conducts, the voltage across it, and that across the capacitor add up harmoniously to give twice the input voltage at the output. Since this process repeats about 10,000 times each second, the output current and voltage is fairly steady.

Amrit Bir Tiwana, India

## Digital Potentiometer



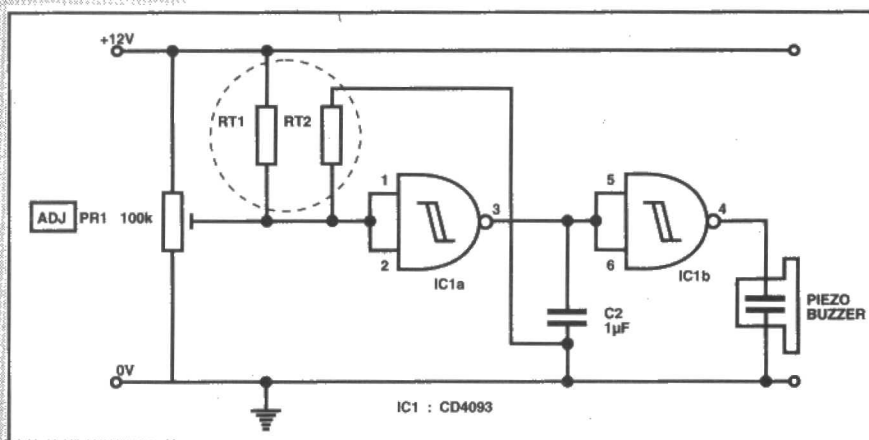
**A**t times, a digitally controlled potentiometer can be more useful than a manual one. One reason being that it can be controlled from more than just one location. Another can be, that such a device at least the one described here can have resistances up to megohms for which variable resistors are not commonly available. And of course such a device can be preprogrammed by attaching to a timing control, to say dim lights etc etc.

The present circuit uses an up-down CMOS counter type

4029 which is made to count up and down by SW1 & SW2 respectively. The oscillator built around one of six inverters of the hex schmitt inverter type 40106 provides a clock pulse of about 1Hz which automatically clocks the counter if the up/down controls are held down. The selection/variation is done in 16 equal steps, by the bi-directional static switches in the CMOS switch type 4016. The only point to note is that R1, R2, R3, R4 are twice the value of the preceding resistors.

Amrit Bir Tiwana, India

## Gas Leakage Detector



**T**he circuit design described here is that of an austere gas leakage detector, built around a single quad schmitt NAND gate CMOS integrated circuit type 4093 - only two of the four available gates are used. The circuit is capable of effectively detecting the presence of a majority of the inflammable gases (such as

butane, iso-butane etc) on time enough to avert any potential damage.

A special sensor forms the heart of the circuit. This consists of a Platinum coil, coated with chemical oxidation catalysts, which oxidises the above gases. When the concentration of the gases crosses a preset safe level; owing to the fall of resistance of the coil sensor the input of IC1a goes low, and its output goes high. This in turn activates the alarm generator, BZ1 a Piezo buzzer. The sensitivity of the detector is specifically adjusted with the help of PR1.

Since the sensitivity is affected by the ambient conditions, and not just the concentration of the gas, a compensator resistance, RT2 is introduced into the circuit, at the input of NAND gate IC1a. C1 is deliberately introduced to prevent false triggering.

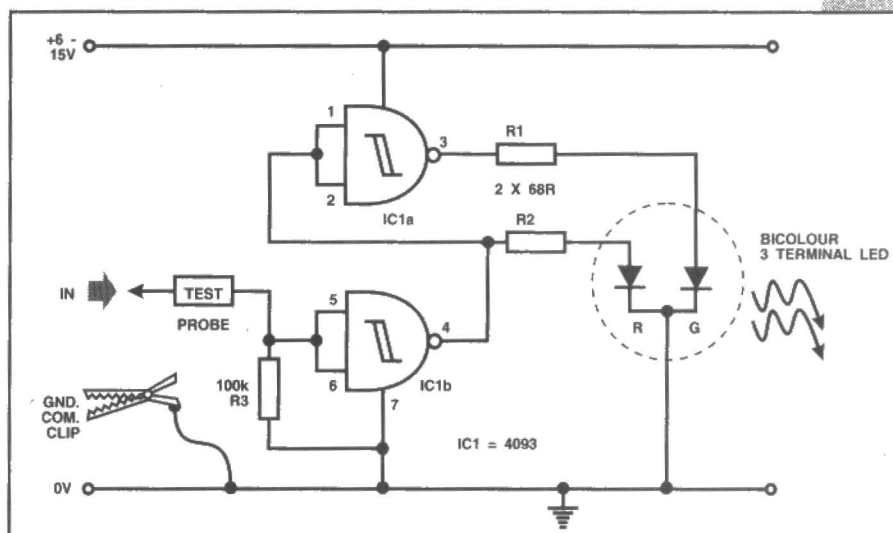
The dependability of the circuit is, to a fair extent dependent on the placement of the sensor (the compensator & sensor are packaged in a steel wire framed mesh), which optimally must be placed somewhere around the ceiling.

Amrit Bir Tiwana, India

## Duty Cycle Indicator

**T**he logic probe unlike most other hand held probes, can distinguish not only between LO-HI and PULSE levels states of digital circuits, but also give a fair approximation of duty cycle of the signal input. This is a rather useful indication of fault isolation in digital circuitry.

The circuit is based on a CMOS quad NAND type 4093, only two of the four gates being used in this design. Initially the Red LED is lit indicating no signal or Low logic. On applying an input, if the status of the bi-colour LED display changes to green, it indicates high logic. If it alternates visibly between red and green, it implies that the point under test has a pulse train at the frequency of the LED alternation. If the frequency exceeds 20Hz, then the duty cycle becomes significant as the

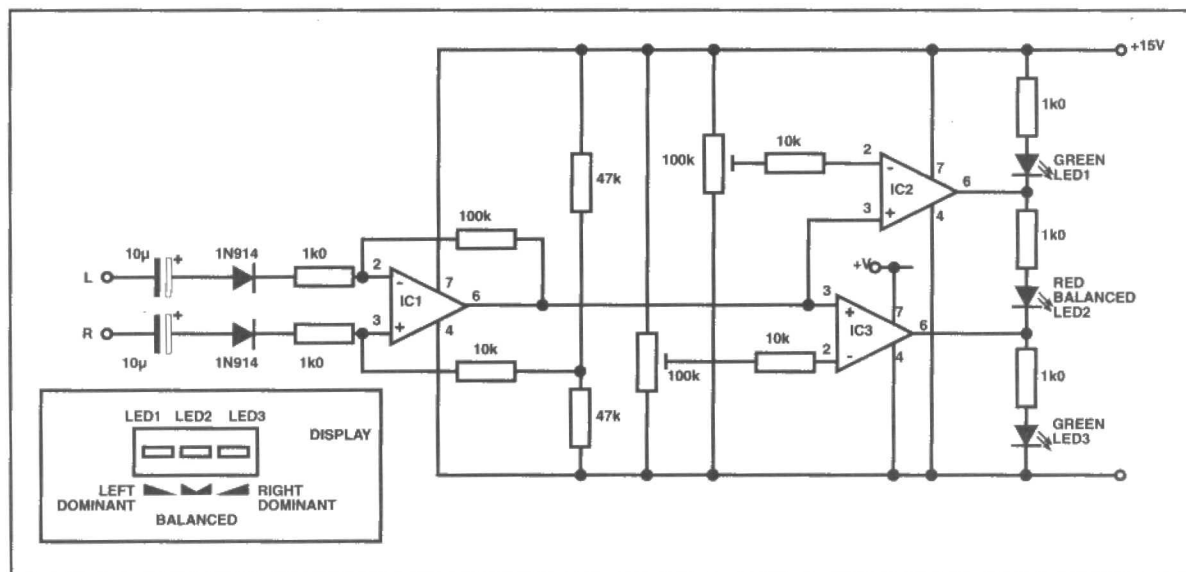


effective colour is not green or red but intermediate.

After just some time, you will be aquanted, and from the intensity of the RED GREEN and orange portions or the shade of orange, the duty cycle can be approximated fairly. For example a bright pure orange display shows about 50% duty cycle, which may be approximated at 45-55% and so on.

Amrit Bir Tiwana, India.

## Stereo Balance Meter



**B**alance on a stereo amplifier is usually set by ear, but this of course can be very difficult to judge. If an amplifier has a balance meter at all, it is usually of the centre-zero moving coil type bulky, old-fashioned looking and expensive. This circuit is designed to overcome all of these problems.

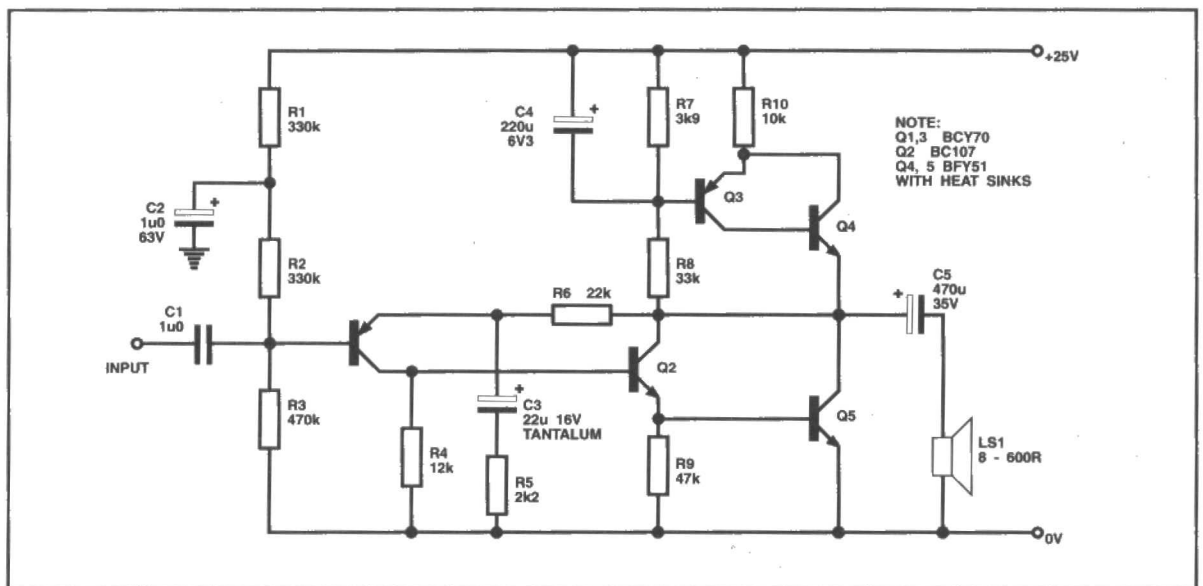
The outputs from each channel are fed to the two inputs of IC1, this being connected as a differential amplifier. If the left and right channels are of equal levels, the output of IC1 will have its output at about halfway between the supply rails. If the left channel gets above the level of the right channel, the output of IC1 will approach the 0V rail. If the right channel is loudest, the output becomes positive.

IC2 and 3 are also differential amplifiers, but in this case they are driven by the output of IC1. LEDs form a display at the outputs of the two ICs. Pin 2 of ICs 2 and 3 each go to a preset across the supply. In practice, the preset in conjunction

with IC2 is set to hold pin 2 slightly above 0V and the preset connected to IC3 is set to hold pin 2 just below supply voltage. These settings, however, must be set by trial and error so that the circuit works accurately.

The output of IC1 is connected to the non inverting inputs of IC2 and 3. If the output of IC1 approaches the supply rail, the outputs of ICs 2 and 3 will also go high, thus illuminating LED 3. This would happen if the right channel were dominating. If the left channel were dominant, the outputs of ICs 2 and 3 would be low, thus illuminating LED 1. If the two channels were equal in amplitude, the outputs of ICs 2 and 3 would be high and low respectively, lighting up LED 2.

The circuit can easily be added on to a ready constructed unit without using up large amounts of panel space, or used as an add-on unit for a hi-fi system. The unit draws about 20mA, so battery operation is practical.



## High Quality Headphone Amplifier

**T**his circuit is capable of high performance using low cost, readily available components. The class A amplifier is designed to drive efficient, high impedance headphones of 150R and above, although it will drive 8R headphones with reduced performance.

Feedback is applied by R1,2 and gain with the specified components is 11. For maximum output the input sensitivity is 0dB. Q3,4 and C4 form a gyrator circuit and present a high

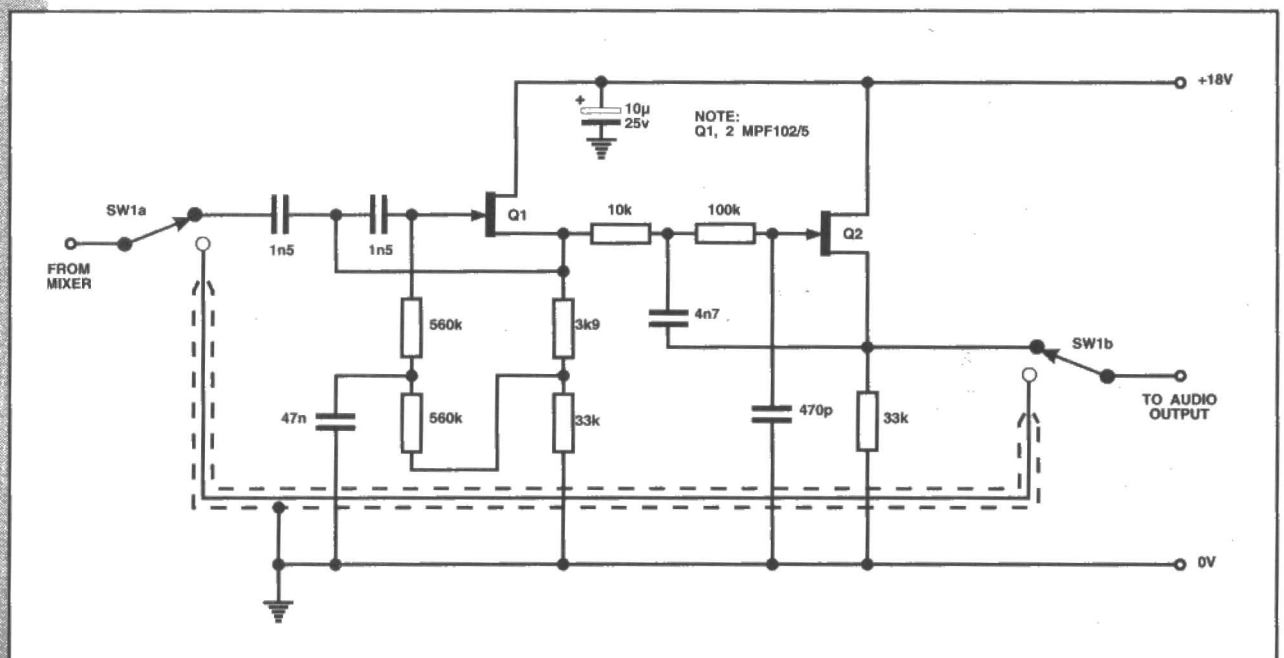
impedance to A6 signals. This gives the circuit a high open-loop gain. Quiescent current is set by R9 (approximately 60mA).

Performance is good with distortion and noise measured on Radford test kit at less than 0.01% for maximum output. Noise is less than -80dB unweighted. Power bandwidth is less than 10Hz to over 50kHz. Slew rate is greater than 5V/ $\mu$ s.

## Active Audio Filter

**T**he main drawback of passive IF filters is their insertion loss when using inductors, necessitating the use of a two or three stage high-gain preamp to compensate for this loss. With an active audio filter the insertion loss can be low, non-existent or even provide gain. In this FET filter there is virtually no insertion loss.

When this filter is incorporated in a receiver and switched in, there is an apparent improvement in the signal-to-noise ratio and readability of signals. High and low frequency heterodynes and audio chatter outside the filter passband are quite noticeably attenuated, making listening more pleasant.



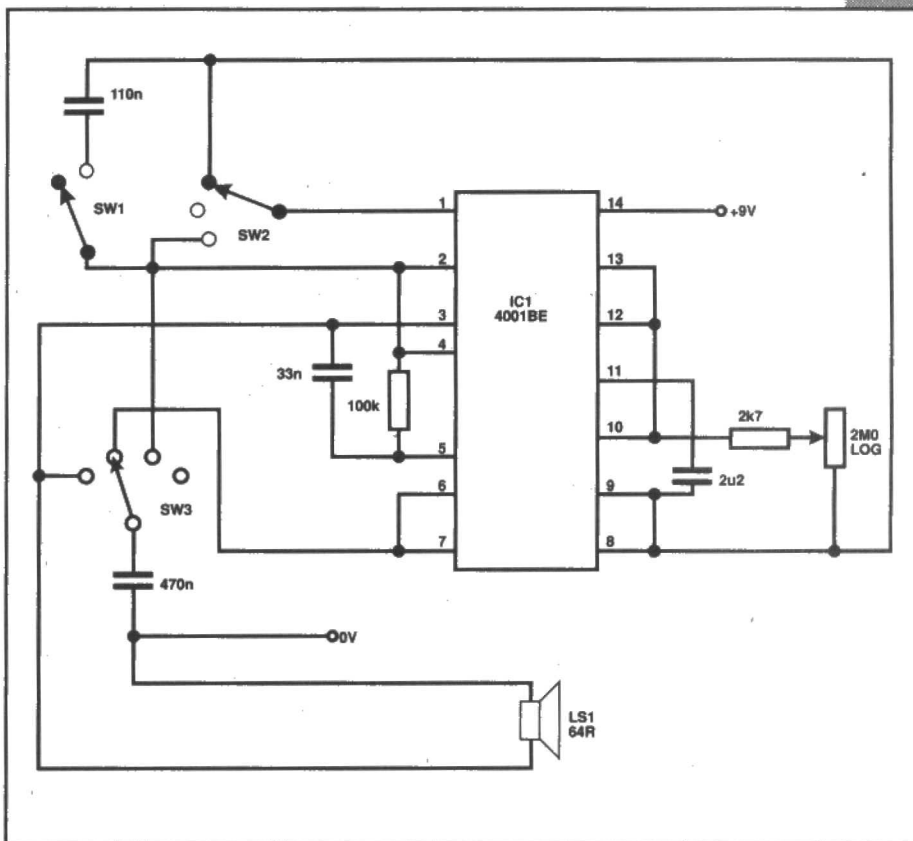
# Simple Sound Effects

**T**his circuit will generate 24 different sound effects including two-tone sirens, rising tones, seagulls etc.

It operates from a 9V battery and uses only one CMOS IC. Most of the components are not critical, but the speaker must have an impedance 64-100R. Note that the negative supply from the battery does not go to the negative supply pin on the IC, which must be the buffered version of the 4001.

Altering the 33nF capacitor or 100k resistor changes the basic frequency, and the 2MΩ pot adjusts the speed of the rise and fall of the tones. A PP6 battery was used to drive the circuit and has been in regular operation for six months without replacement.

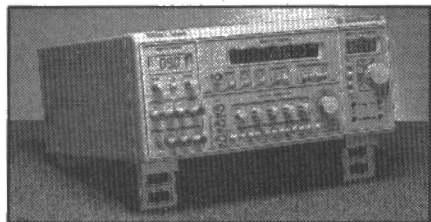
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## QUALITY INSTRUMENTS AT EXCEPTIONAL VALUE

### MULTI INSTRUMENT

MX9000

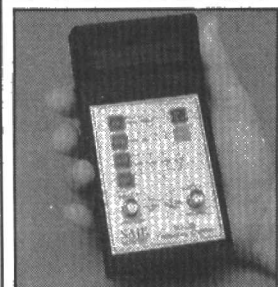


### DIGITAL MULTIMETERS

183, 185, 187, 285



### COUNTERS SC-130, SC-40 LCR METER MIC-4070D



### MULTI INSTRUMENT

The MX9000 combines four instruments to suit a broad range of applications in both education and industrial markets including development work stations where space is at a premium.

The instruments include:

1. A triple output power supply with LCD display offering 0-50V 0.5A, 15V 1A, 5V 2A with full overcurrent protection;
2. An 8 digit LED display 1Hz - 100MHz frequency counter with gating rates of 0.1Hz, 1Hz, 10Hz and 100Hz providing resolution to 0.1Hz plus attenuation inputs and data hold;
3. A 0.02Hz to 2MHz full featured sweep/function generator producing sine, square, triangle, skewed sine, pulse and a TTL output and linear or logarithmic sweep. Outputs of 50Ω and 600Ω impedance are standard features;
4. An auto/manual 3 1/2 digit LCD multimeter reading DCV, DCA, ACV, ACA, resistance, and relative measurement with data hold functions.

The MX9000 represents exceptionally good value at only £399.00 plus VAT (468.83).

### DIGITAL MULTIMETERS

The 180 series of high performance multimeters provide advanced features and are supplied complete with probes, battery and rubber holster. The case is dust and splash proof making it ideal in most environments. Designed to meet IEC348 Class II safety standard.

- 183 - 3 1/2 digit large LCD display, ACV, DCV, ACA, DCA resistance, continuity buzzer, diode test, hold, basic accuracy 0.5%, £39.50 plus VAT (46.41).
- 185 - 3 1/2 digit LCD, bar graph, ACV, DCV, ACA, DCA, resistance, continuity buzzer, diode test, hold, temperature (-40°C to 1370°C), capacitance (1pF to 40uF), frequency (1Hz to 200kHz), max min, edit, % compare, basic accuracy 0.3%, £74.50 plus VAT (£87.54).
- 187 - 3 1/2 digit LCD, bar graph, ACV, DCV, ACA, DCA, resistance, continuity buzzer, diode test, hold, temperature (-40°C to 1370°C), frequency (1Hz to 200kHz), max min, edit, %, compare, basic accuracy 0.3%, auto ranging, £99.50 plus VAT (£116.91).
- 285 - As 185 except 4 1/2 digit true RMS, basic accuracy 0.05%, £109.50 plus VAT (128.66).

### FREQUENCY COUNTERS

The SC-130 and SC-40 are full featured, micro processor based, hand held frequency counters providing portability and high performance. Both instruments provide measurement of frequency, period, count and RPM plus a view facility enabling min, max, av and difference readings.

SC-130: 5Hz 1.3GHz, 8 digit readout, sensitivity typically 10mV, high impedance input, battery condition indicator. £109.00 plus VAT (128.08)

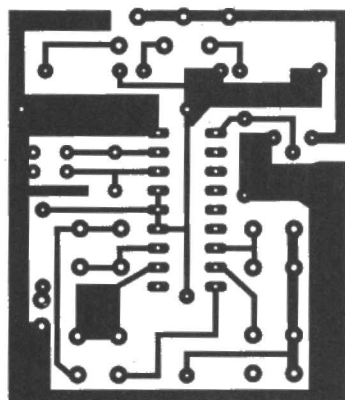
SC-40: As SC-130 except 5Hz to 400MHz. £89.00 plus VAT (£104.58)

### LCR METER

The MIC-4070D LCD digital LCR meter provides capacitance, inductance, resistance and dissipation measurement. Capacitance ranges are from 0.1pF to 20,000uF plus dissipation. Inductance ranges from 0.1pH to 200H plus a digital readout of dissipation. Resistance ranges from 1mΩ to 20MΩ. Housed in a rugged ABS case with integral stand it is supplied complete with battery and probes at £85.00 plus VAT (£99.88).

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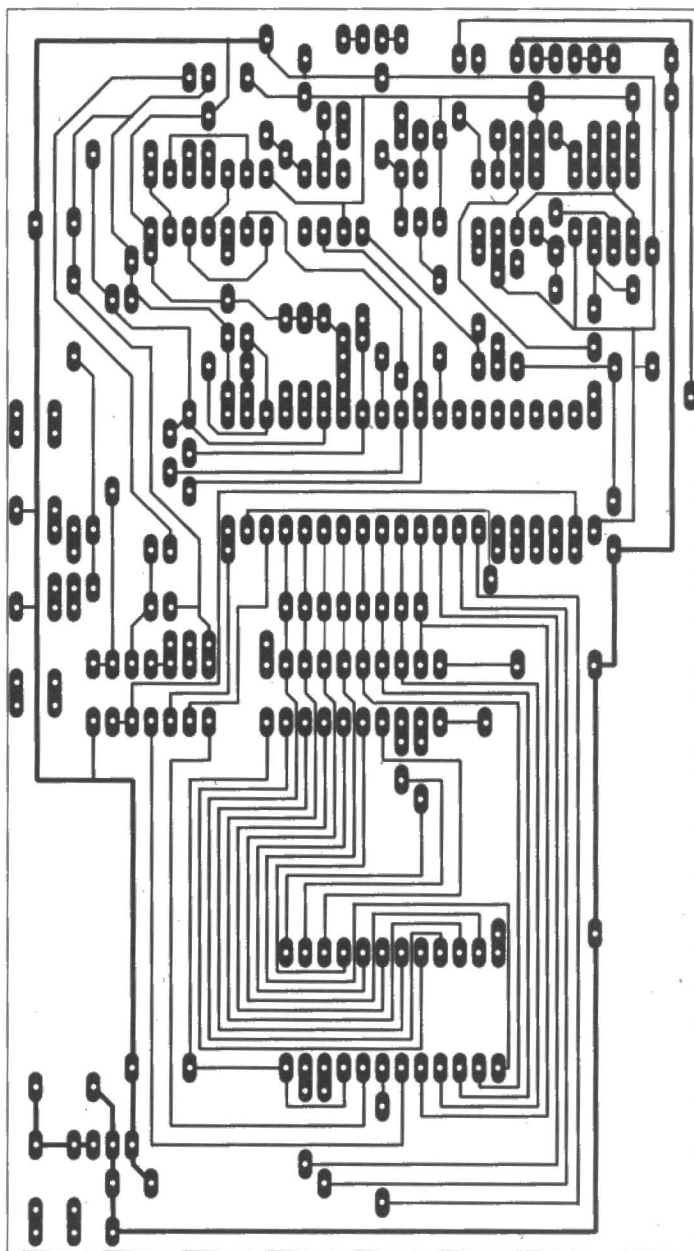
For further information contact SAJE now on tel (0223) 425440 or fax (0223) 424711, or for fast delivery send your order direct enclosing cheque/postal order made payable to SAJE ELECTRONICS to: SAJE Electronics, 117 Lovell Road, Cambridge, CB4 2QW. Free postage for UK orders, for overseas orders add £10.00. Trade orders welcome.



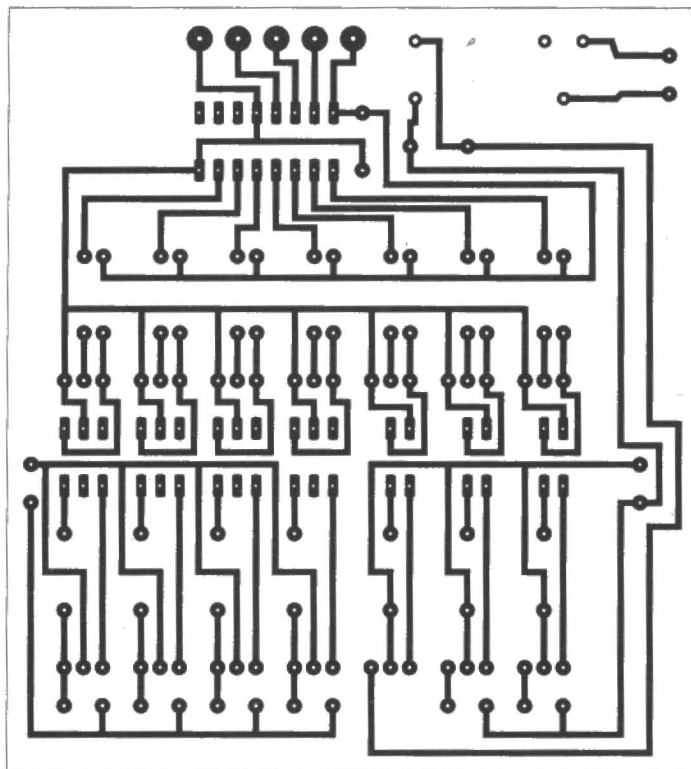
IR Transmitter

# PCB Foils

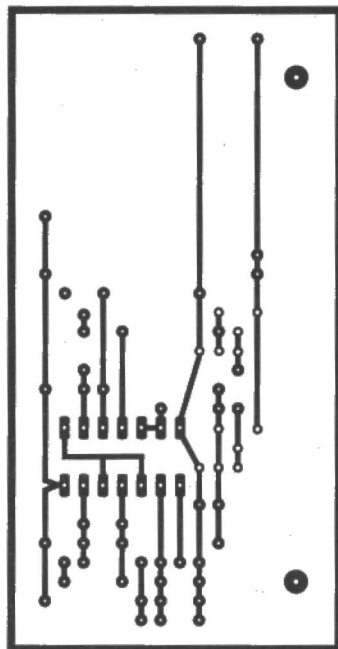
The PCB foil patterns presented here are intended as a guide only. They can be used as a template when using tape and transfer for the creation of a foil.



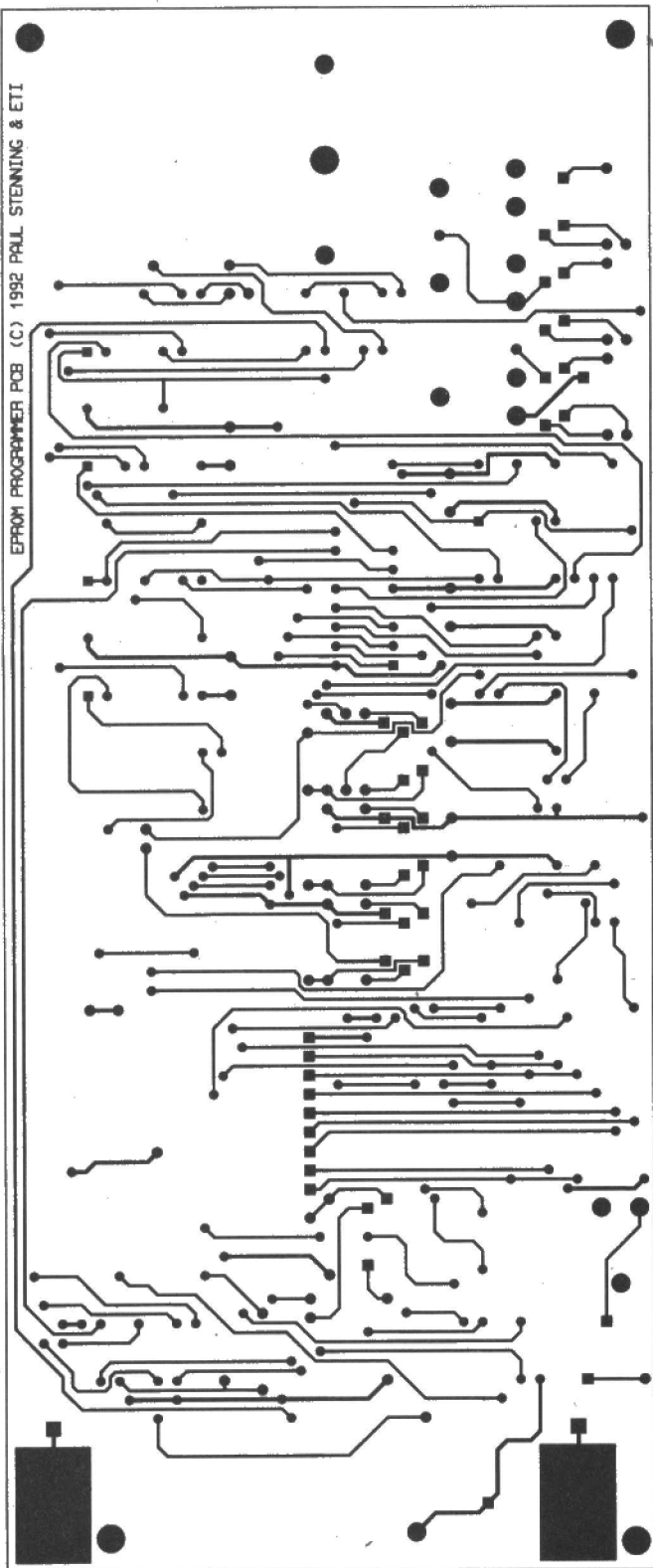
Sound to MIDI



DiscoAmiga (Light selector)

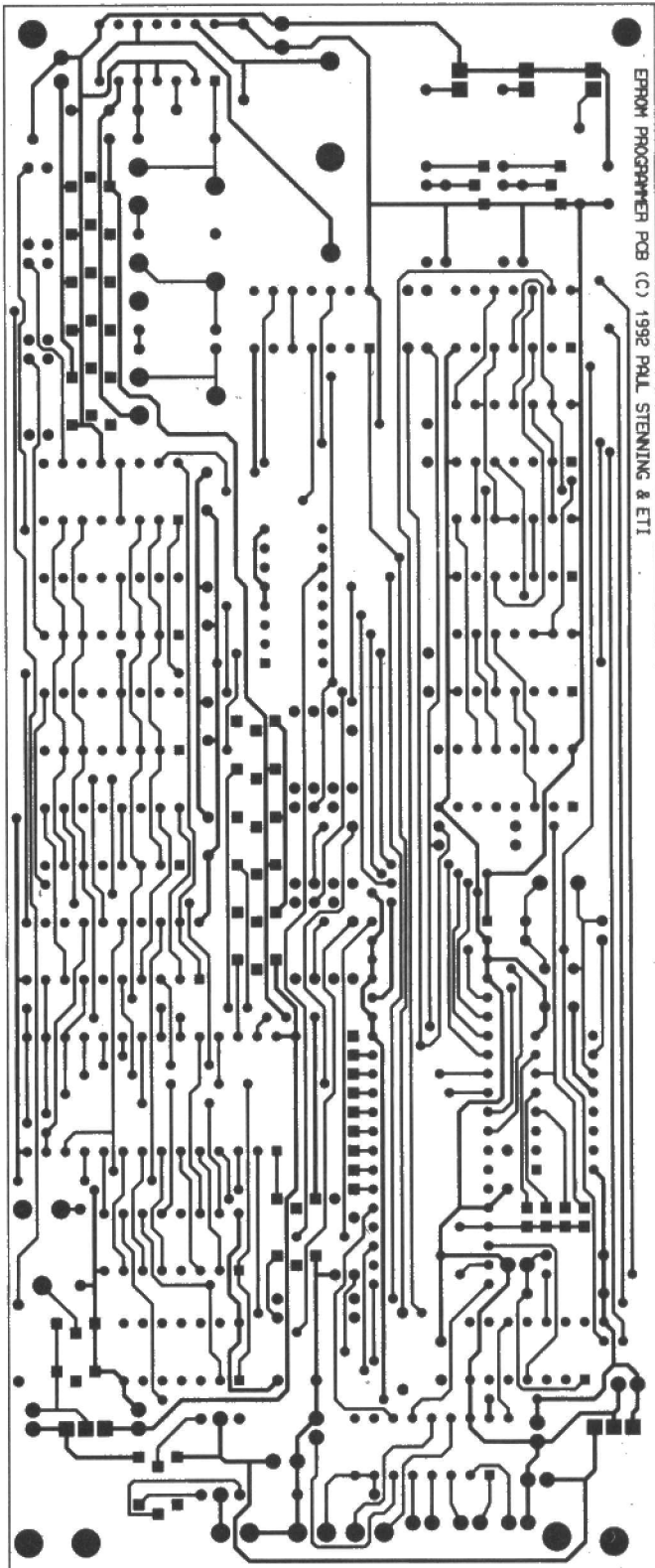


PuddleTec



Top Side

EPROM Programmer



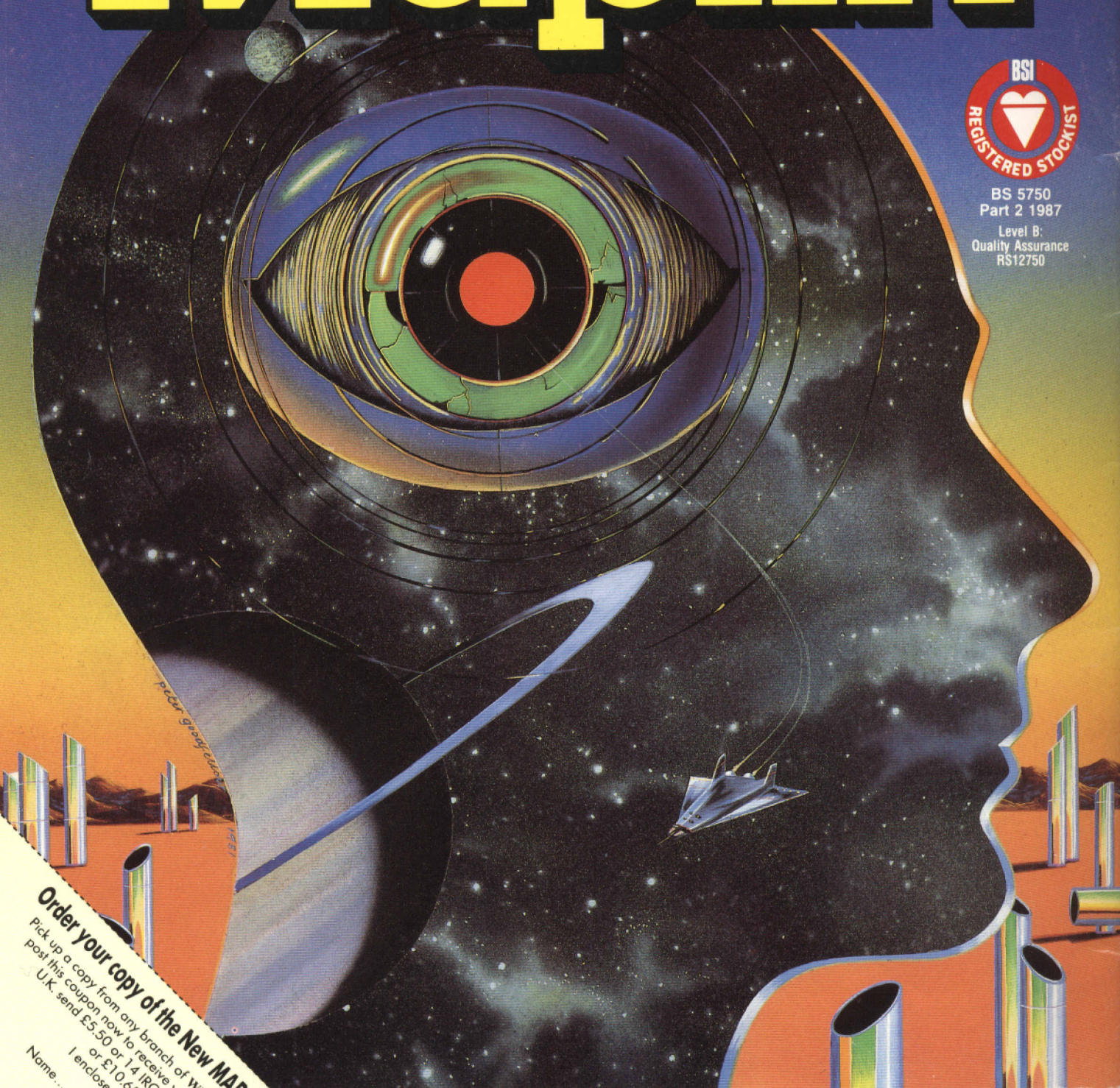
Solder Side

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